Detecting Peering Infrastructure Outages in the Wild

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Peering Infrastructures are critical part of the interconnection ecosystem

Internet Exchange Points (IXPs) provide a shared switching fabric for layer-2 bilateral and multilateral peering.

- Largest IXPs support > 100 K of peerings, > 5 Tbps peak traffic
- Typical SLA 99.99% (~52 min. downtime/year)[1]

Carrier-neutral **co-location facilities** (CFs) provide infrastructure for physical co-location and cross-connect interconnections.

- Largest facilities support > 170 K of interconnections
- Typical SLA 99.999% (~5 min. downtime/year)[2]

[1] https://ams-ix.net/services-pricing/service-level-agreement [2] http://www.telehouse.net/london-colocation/

Outages in peering infrastructures can severely disrupt critical services and applications

DOWNTIME WOES —

BT, other ISPs hit by second major Internet outage—power failure blamed

After Telecity power outage, it seems Telehouse has had problems of its own.

KELLY FIVEASH - 21/7/2016, 03:05

BT broadband users hit by second UK-wide outage in two days

Caroline Donnelly
Datacentre Editor
21 Jul 2016 9:50

Power supply issues at Docklands datac
behind loss of internet access for more t
broadband users

Equinix cooling outage leads to flight delays in Australia

13 November 2012 | By Penny Jones

Share Tweet Like 0

A "short interruption to utility power supply" at an Equinix data center in Sydney caused up to three hour delays for thousands of passengers flying with three major airlines from Australian airports over the weekend.

DOWNTIME

Equinix Outage Means Downtime for Zoho

BY RICH MILLER ON JANUARY 20, 2012 ADD YOUR COMMENTS

A power outage Friday morning in an **Equinix** data center in California caused problems for a number of customers, most ably Zoho, which experienced hours of downtime for veral of its web-based office applications. Equinix nowledged the incident, but did not provide details on cause of the outage at its SV4 facility in Silicon Valley.

TECHNOLOGY | TOP STORIES

OUTAGE AT AMSTERDAM INTERNET HUB AFFECTS MUCH OF NETHERLANDS

By Janene Pieters on May 13, 2015 - 13:11

With additional reporting by Zack Newmark.

A technical fault at the internet hub AMS-IX in Amsterdam caused online problems in several places in the Netherlands for about an hour Wednesday afternoon. The internet hub, one of the most used internet exchanges in the world, announced they resolved the problem shortly after 1:30 p.m.

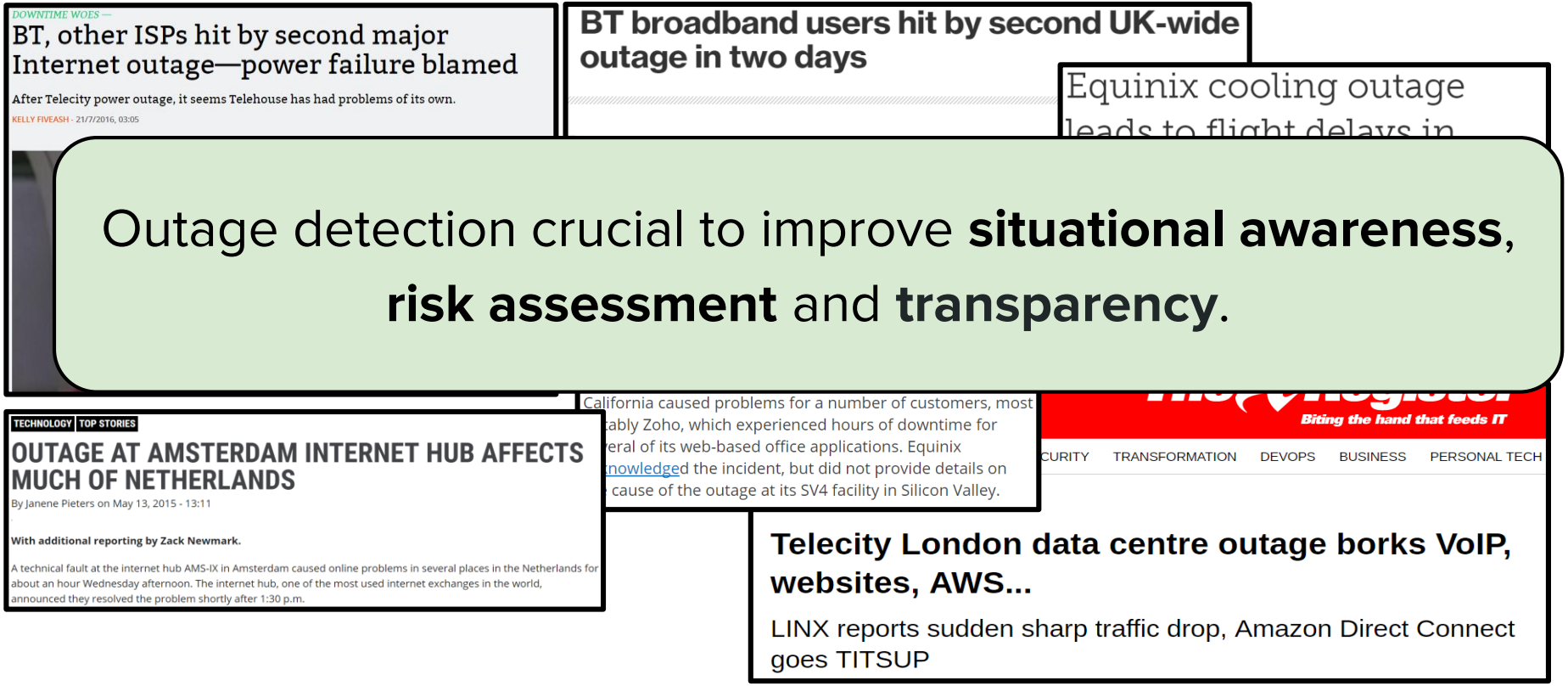
The Register
Biting the hand that feeds IT

CURITY TRANSFORMATION DEVOPS BUSINESS PERSONAL TECH

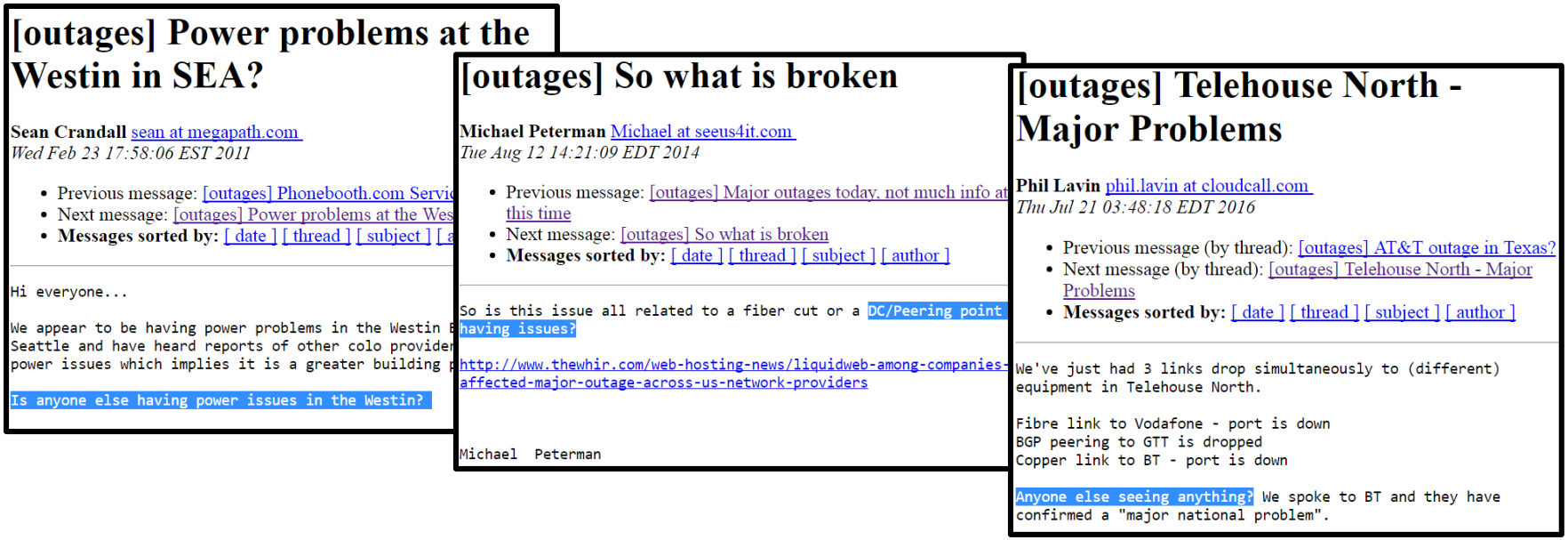
Telecity London data centre outage borks VoIP, websites, AWS...

LINX reports sudden sharp traffic drop, Amazon Direct Connect goes TITSUP

Outages in peering infrastructures can severely disrupt critical services and applications



Current practice: “Is anyone else having issues?”



[outages] Power problems at the Westin in SEA?

Sean Crandall sean at megapath.com
Wed Feb 23 17:58:06 EST 2011

- Previous message: [outages] Phonebooth.com Servi
- Next message: [outages] Power problems at the Wes
- **Messages sorted by:** [date] [thread] [subject] [a

Hi everyone...

We appear to be having power problems in the Westin B
Seattle and have heard reports of other colo provider
power issues which implies it is a greater building p

Is anyone else having power issues in the Westin?

[outages] So what is broken

Michael Peterman Michael at seeus4it.com
Tue Aug 12 14:21:09 EDT 2014

- Previous message: [outages] Major outages today, not much info at this time
- Next message: [outages] So what is broken
- **Messages sorted by:** [date] [thread] [subject] [author]

So is this issue all related to a fiber cut or a DC/Peering point having issues?

http://www.thewhir.com/web-hosting-news/liquidweb-among-companies-affected-major-outage-across-us-network-providers

Michael Peterman

[outages] Telehouse North - Major Problems

Phil Lavin phil.lavin at cloudcall.com
Thu Jul 21 03:48:18 EDT 2016

- Previous message (by thread): [outages] AT&T outage in Texas?
- Next message (by thread): [outages] Telehouse North - Major Problems
- **Messages sorted by:** [date] [thread] [subject] [author]

We've just had 3 links drop simultaneously to (different) equipment in Telehouse North.

Fibre link to Vodafone - port is down
BGP peering to GTT is dropped
Copper link to BT - port is down

Anyone else seeing anything? We spoke to BT and they have confirmed a "major national problem".

- ASes try to crowd-source the detection and localization of outages.
- Inadequate transparency/responsiveness from infrastructure operators.

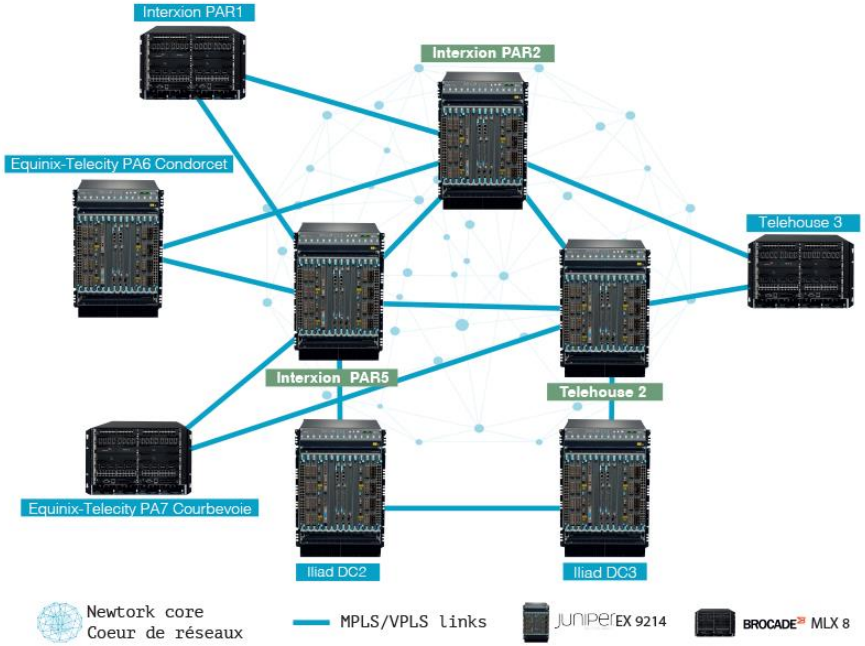
Symbiotic and interdependent infrastructures

DATA CENTER
Network core
Coeur de réseau

1 Interxion PAR2
2 Interxion PAR5
3 Telehouse 2

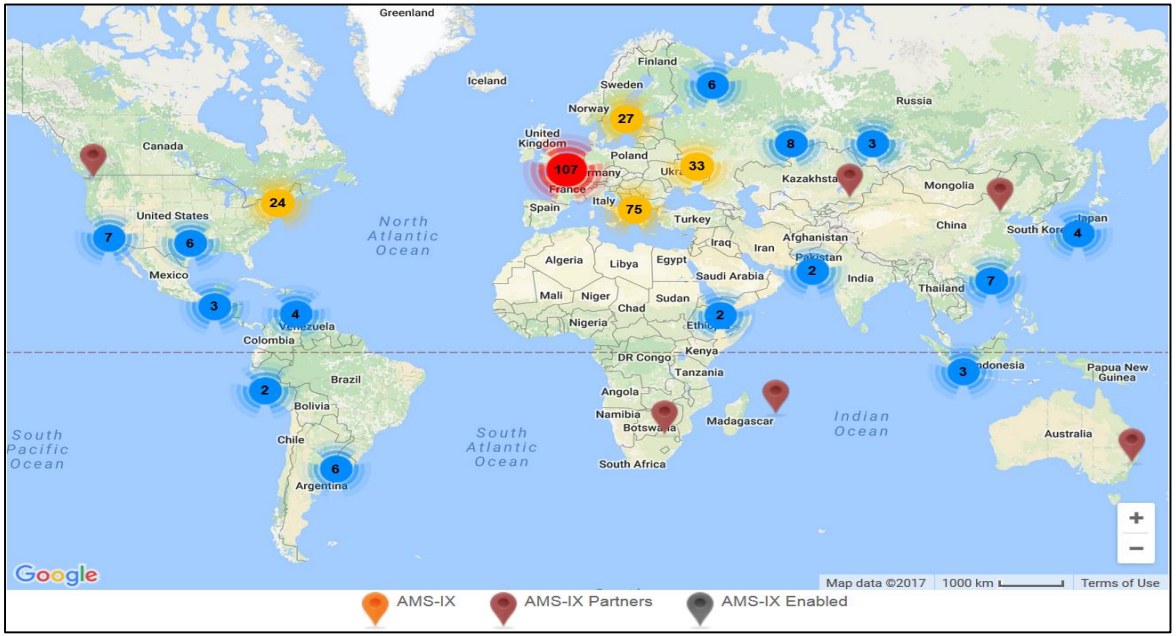
DATA CENTER

4 Iliad DC2
5 Iliad DC3
6 Interxion PAR1
7 Equinix-Telecity PA6 Condorcet
8 Equinix-Telecity PA7 Courbevoie
9 Telehouse 3



https://www.franceix.net/en/technical/infrastructure/

Remote peering extends the reach of IXPs and CFs beyond their local market



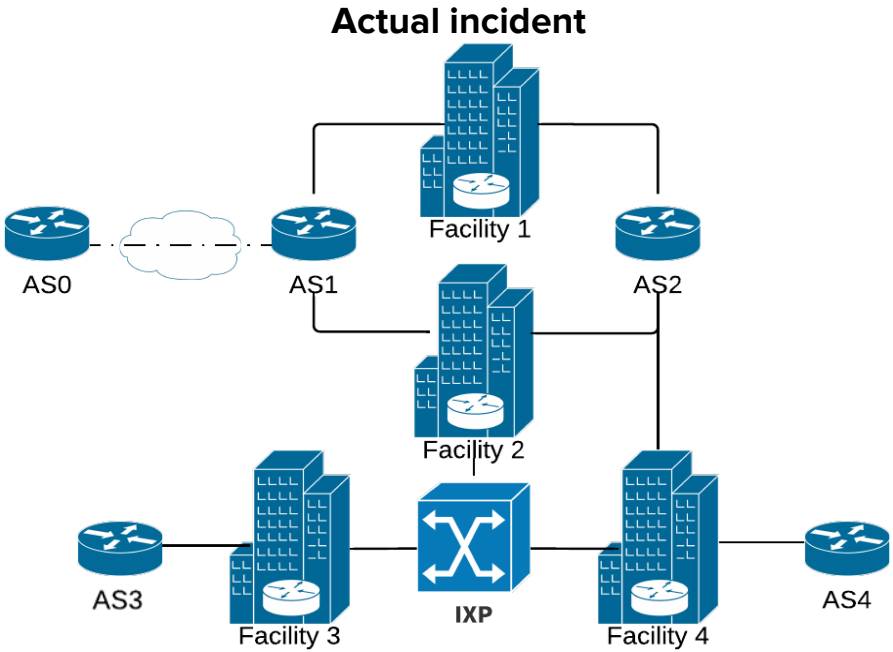
Global footprint of AMS-IX

https://ams-ix.net/connect-to-ams-ix/peering-around-the-globe

Our Research Goals

1. Outage detection:
    - Automated, Timely, Building-level
2. Outage localization:
    - Distinguish *cascading effects* from outage *source*
3. Outage tracking:
    - Determine duration, shifts in routing paths, geographic spread

Challenges in detecting infrastructure outages



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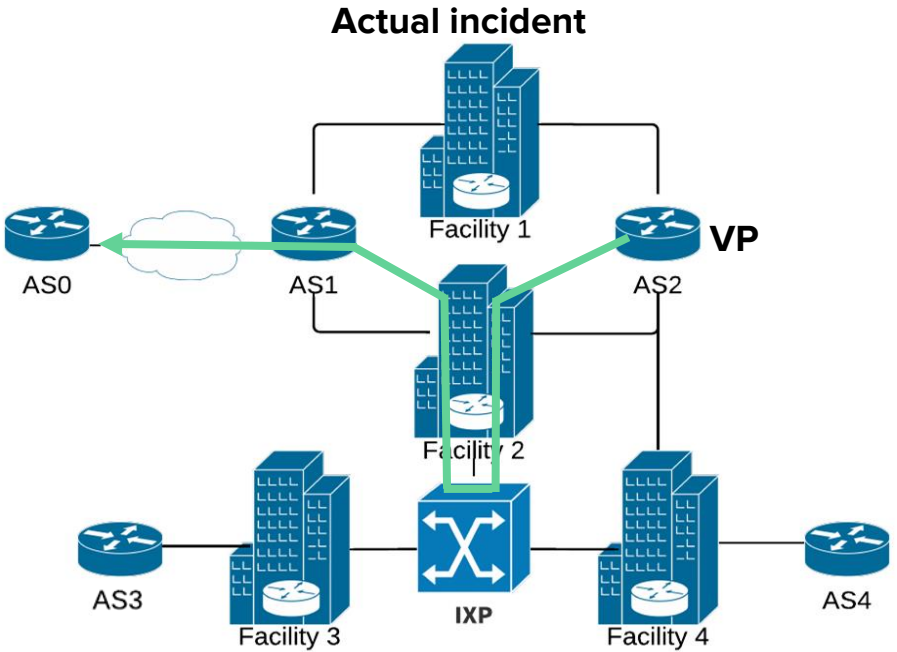

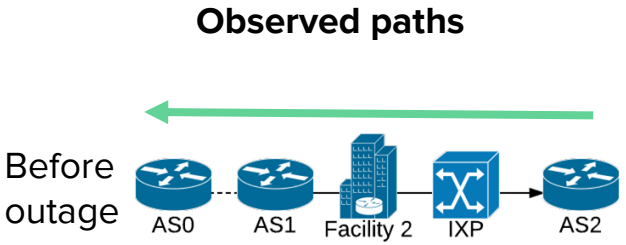

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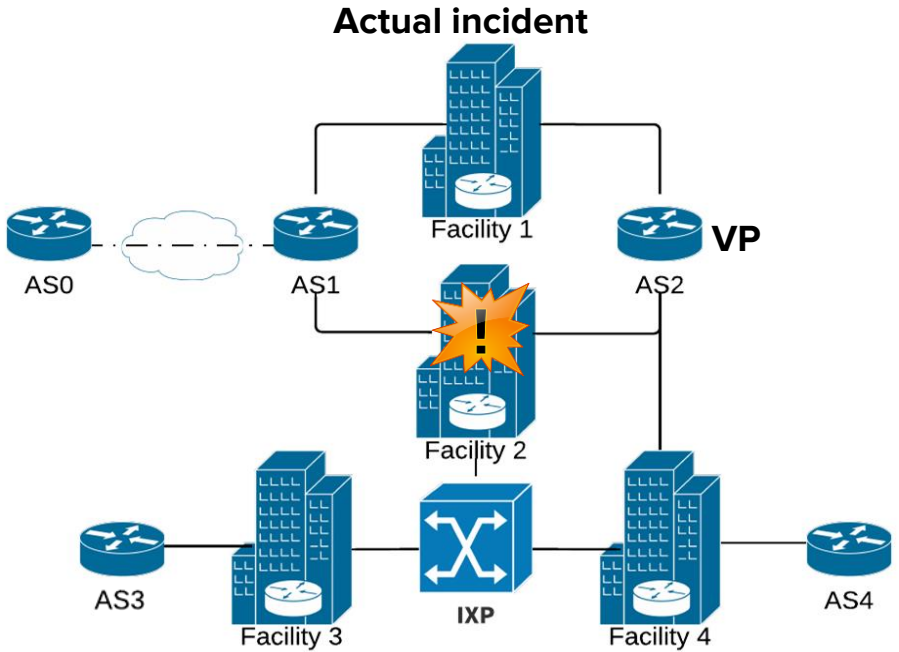

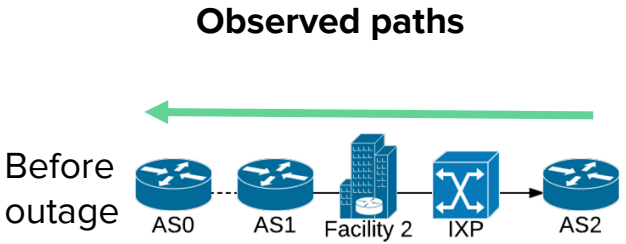

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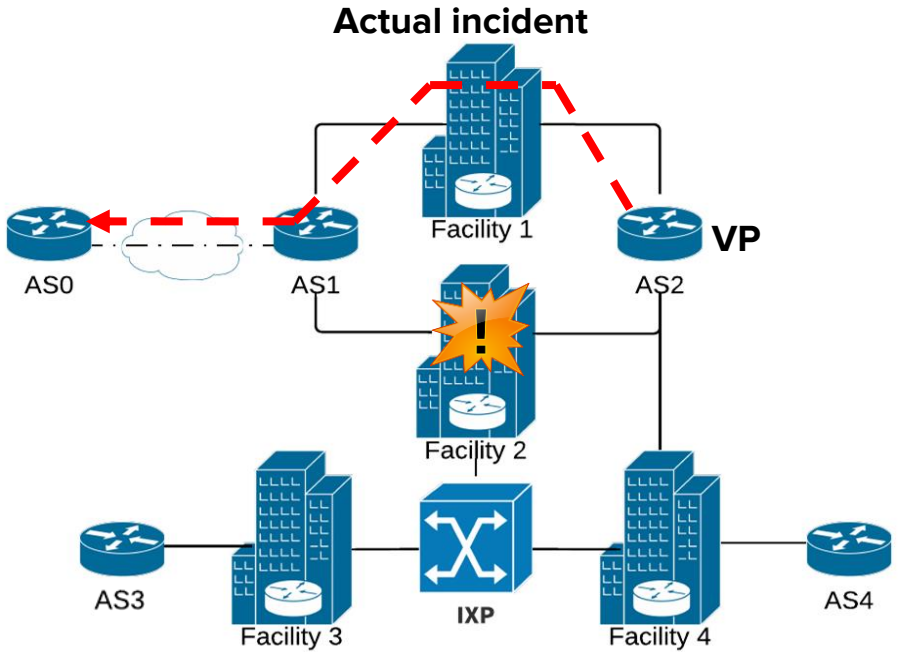
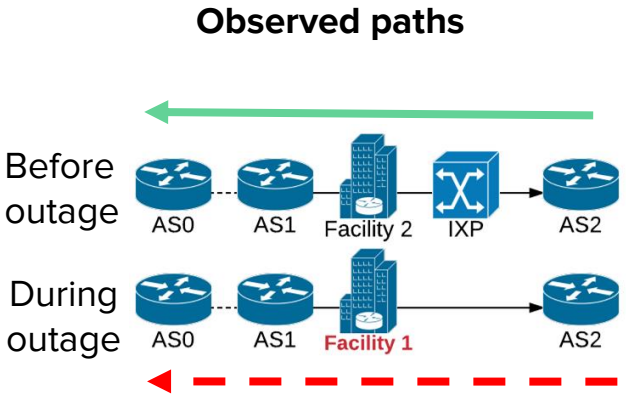
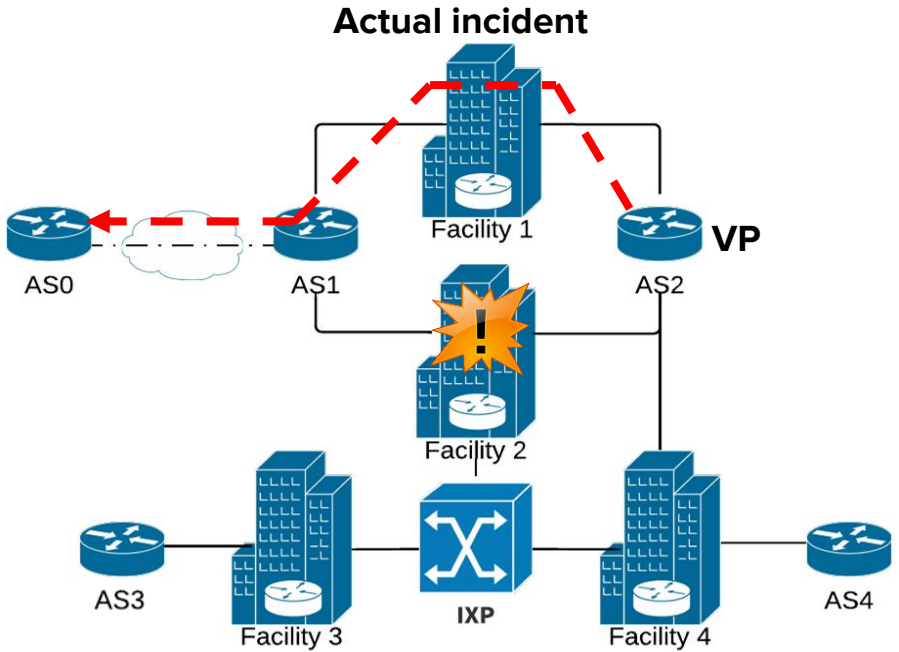
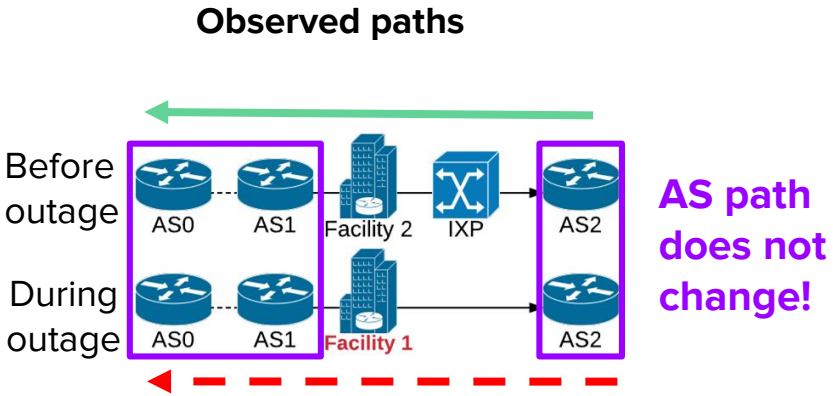




Challenges in detecting infrastructure outages

1. Capturing the infrastructure-level hops between ASes





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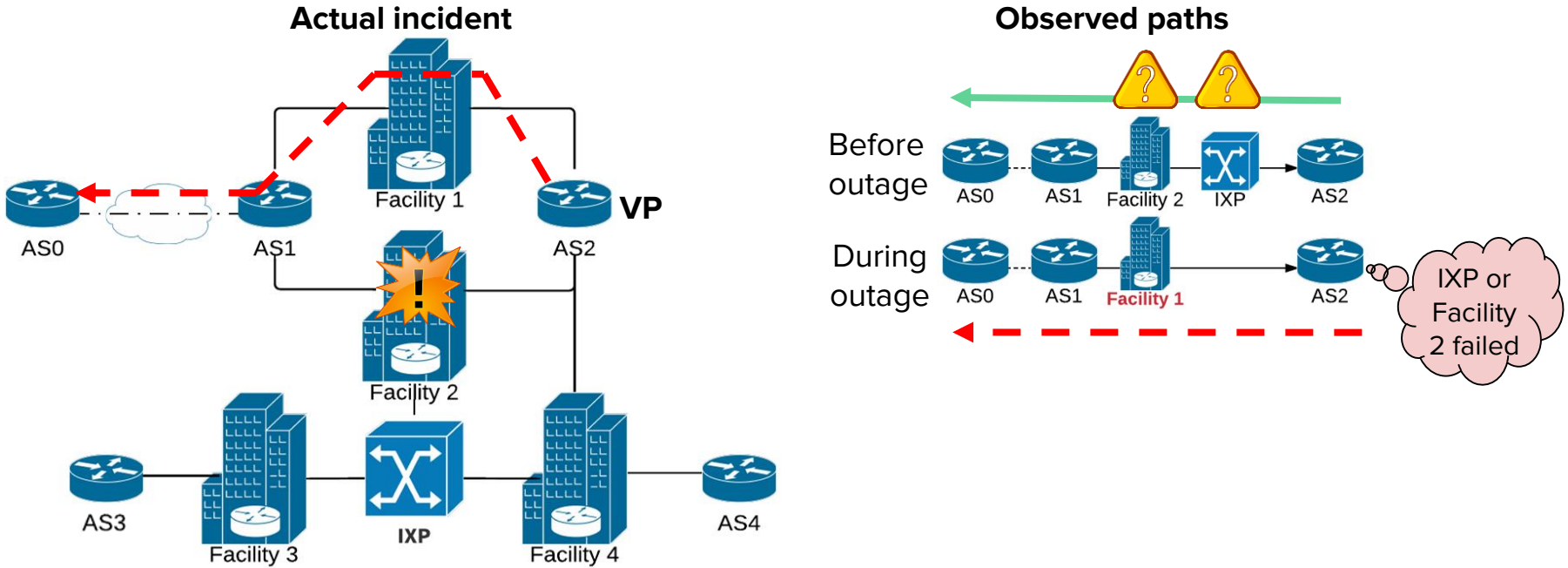

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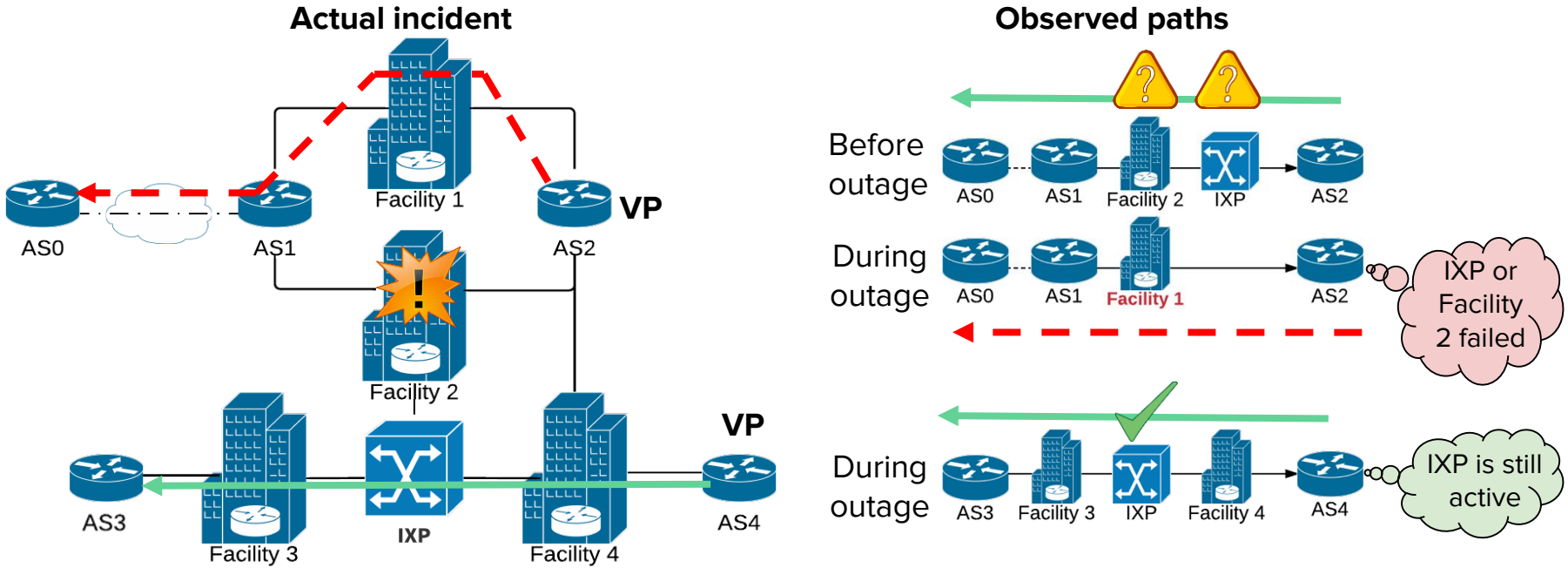
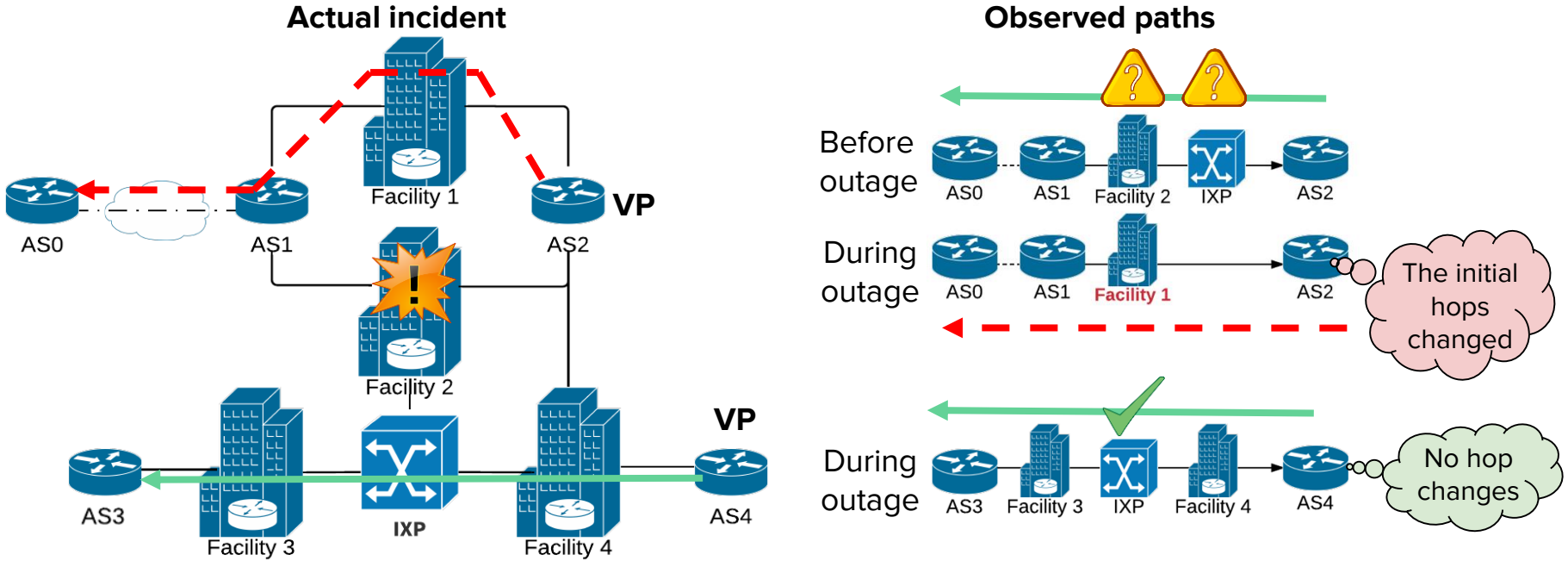
2. Correlating the paths from multiple vantage points



Challenges in detecting infrastructure outages

1. Capturing the infrastructure-level hops between ASes
2. Correlating the paths from multiple vantage points
3. Continuous monitoring of the routing system



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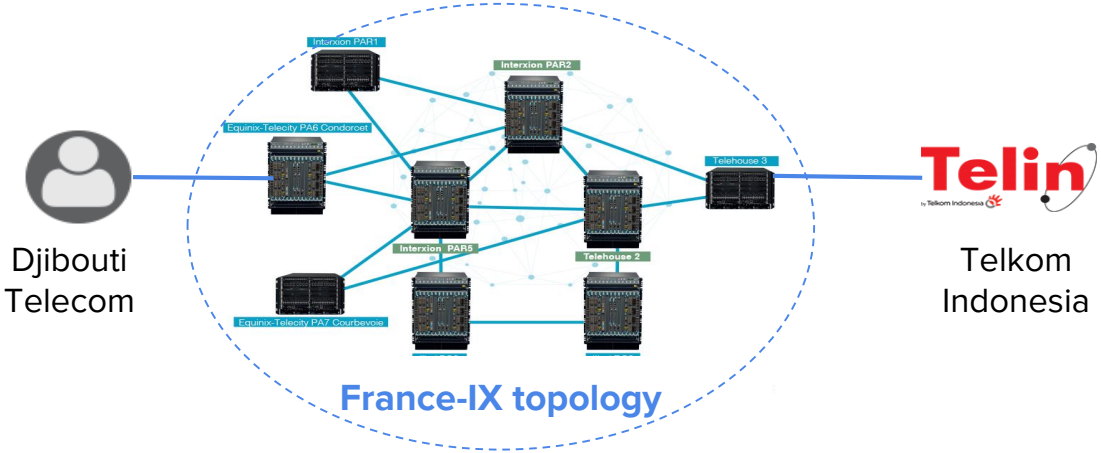

Challenges in detecting infrastructure outages

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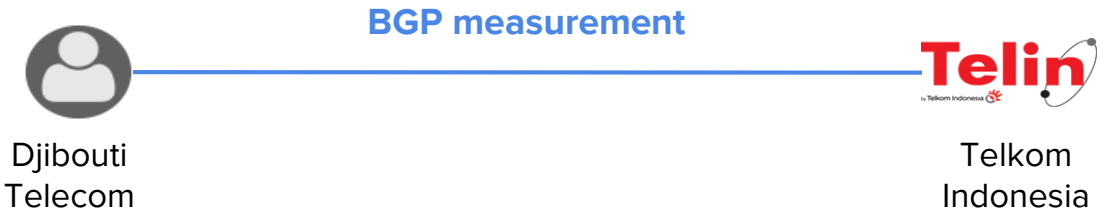
✗ BGP

✓ BGP

✓ BGP



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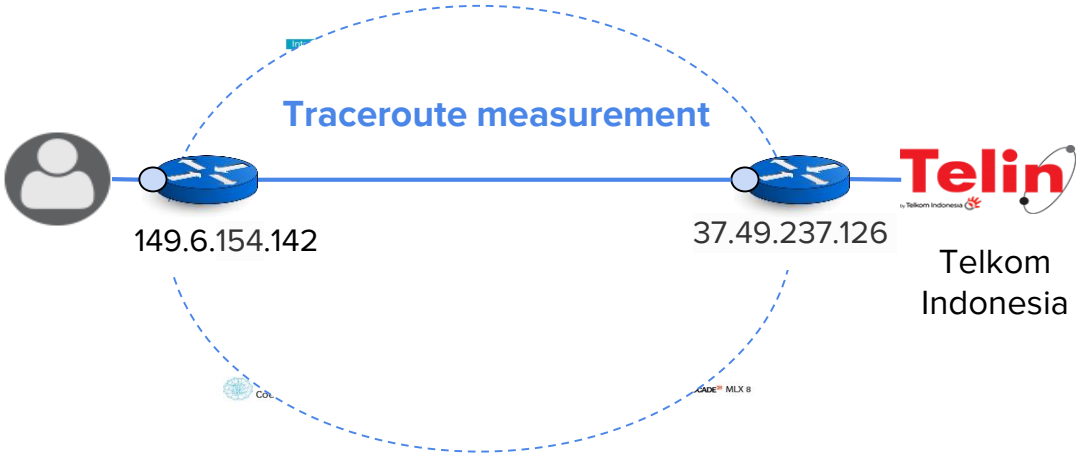

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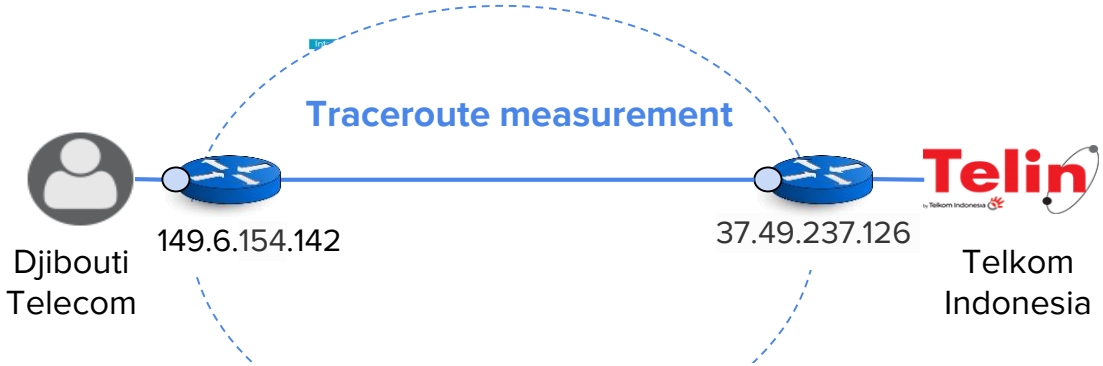
	BGP	Traceroute
✗ / ✓	✗	✓
✓ / ✗	✓	✗
✓ / ✗	✓	✗



IP-to-Facility[3,4] and IP-to-IXP[5] mapping **possible** but **expensive**!

[3] Giotsas, Vasileios, et al. "Mapping peering interconnections to a facility", CoNEXT 2015
[4] Motamedi, Reza, et al. “On the Geography of X-Connects”, Technical Report CIS-TR-2014-02. University of Oregon, 2014
[5] Nomikos, George, et al. "traIXroute: Detecting IXPs in traceroute paths.". PAM 2016

Challenges in detecting infrastructure outages

1. Capturing the infrastructure-level hops between ASes
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Can we combine **continuous passive** measurements with **fine-grained** topology discover?

Challenges in detecting infrastructure outages

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✗ BGP	✓ Traceroute
✓ BGP	✗ Traceroute
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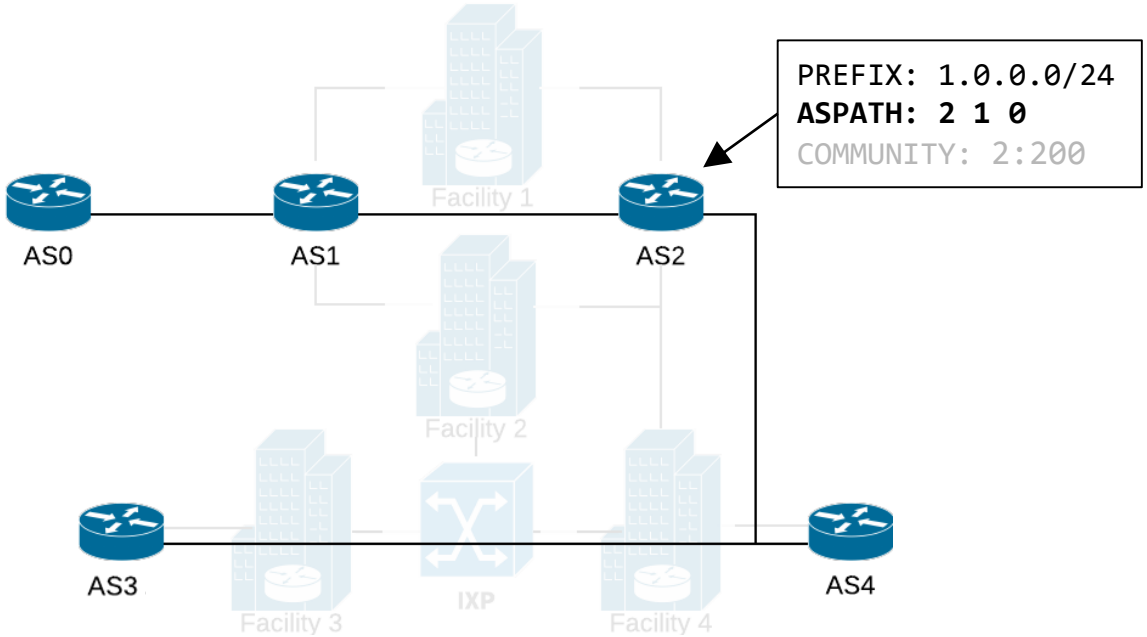
Deciphering location metadata in BGP



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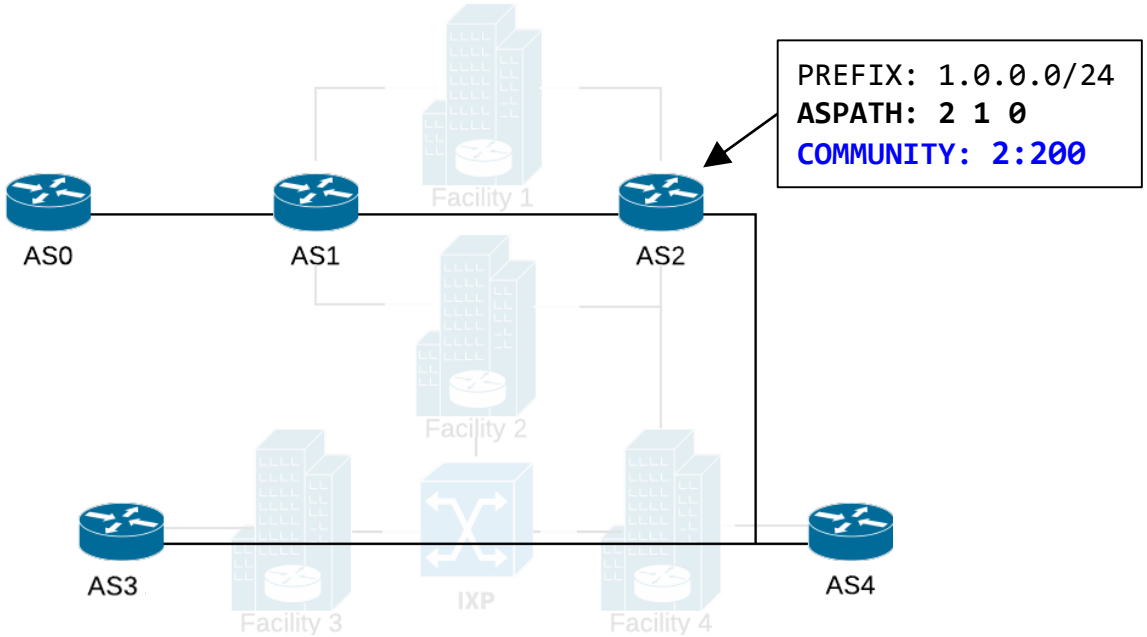
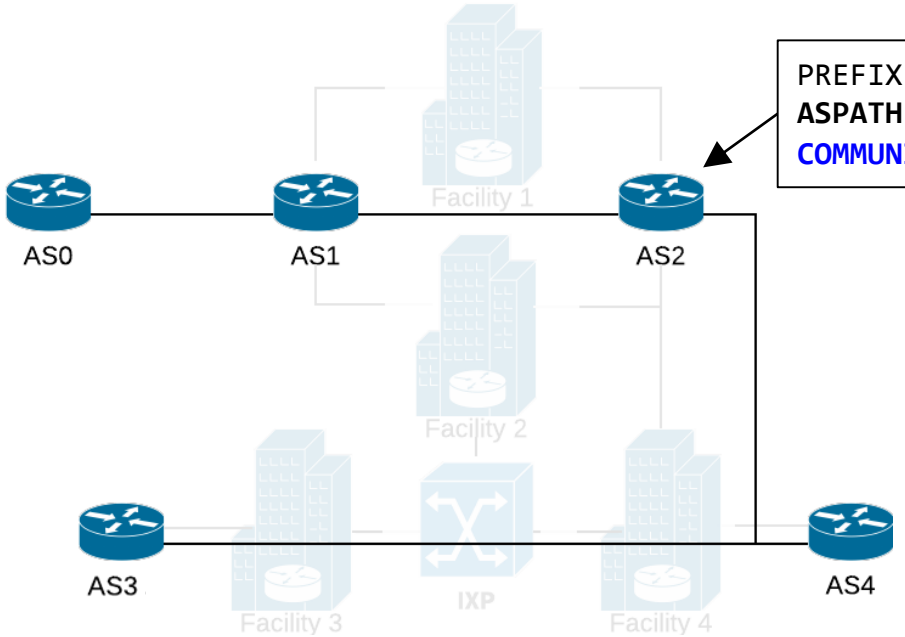


BGP Communities:

- Optional attribute
- Encodes **arbitrary** metadata
- Series of 32-bit numerical values

Deciphering location metadata in BGP

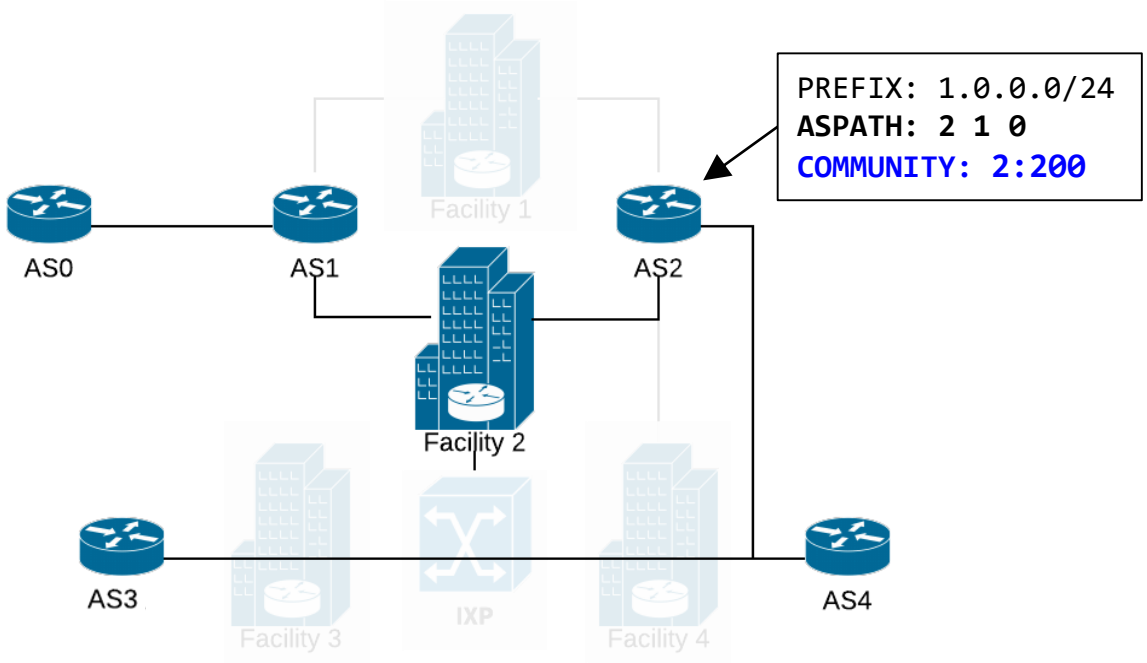



```
PREFIX: 1.0.0.0/24
ASPATH: 2 1 0
COMMUNITY: 2:200
```

Top 16 bits:
ASN that sets the community.

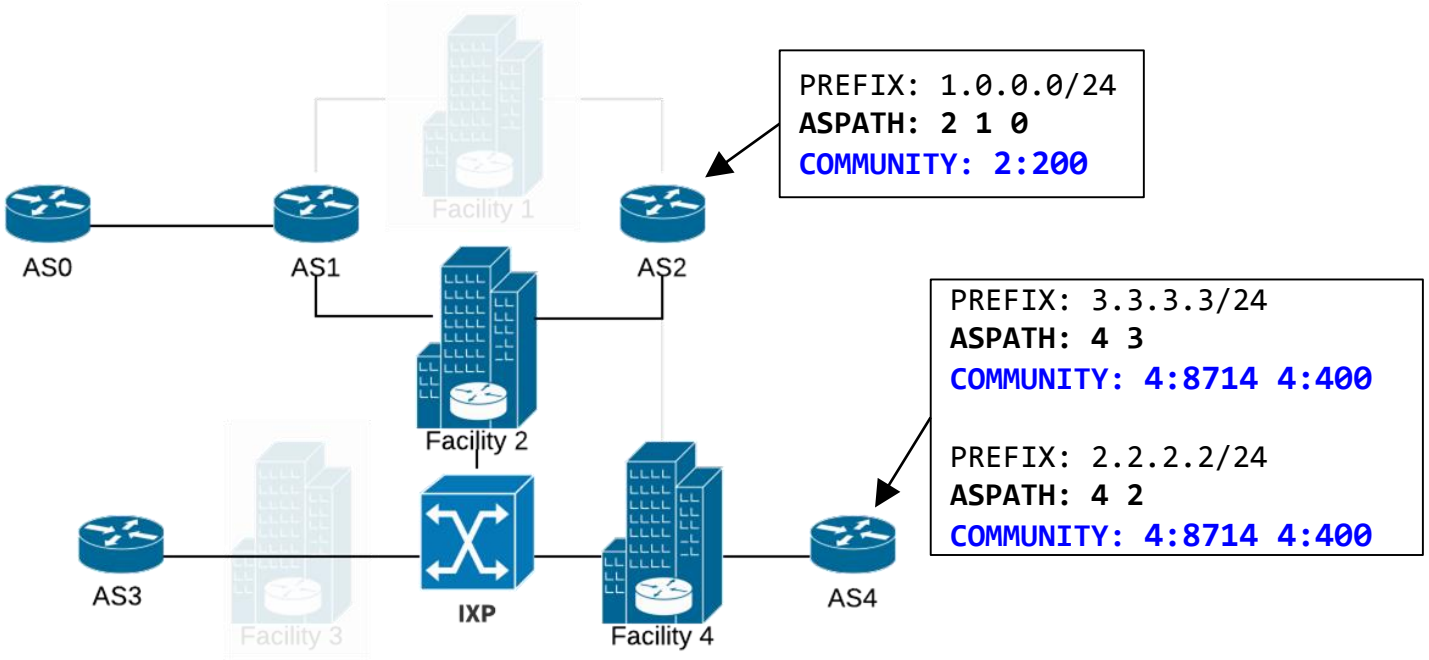
Bottom 16 bits:
Numerical value that encodes the actual meaning.

Deciphering location metadata in BGP



The BGP Community 2:200 is used to tag routes received at Facility 2

Deciphering location metadata in BGP



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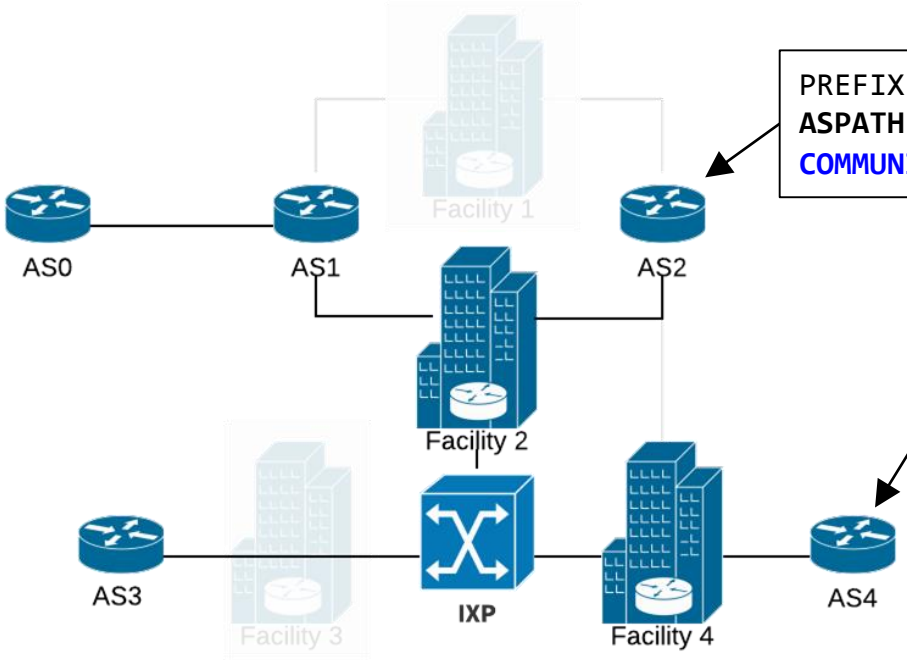


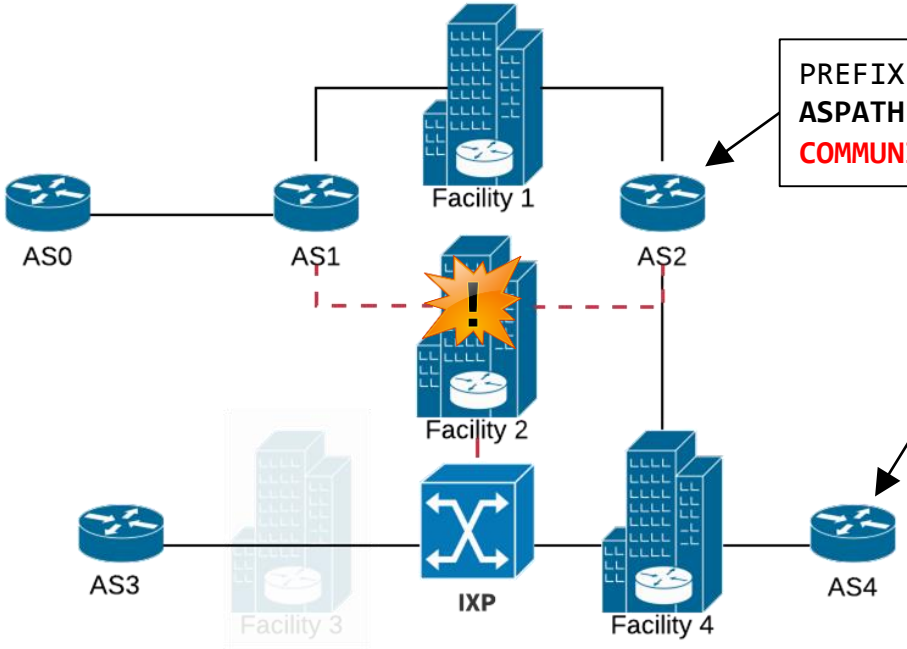

```
PREFIX: 1.0.0.0/24
ASPATH: 2 1 0
COMMUNITY: 2:200
```

```
PREFIX: 3.3.3.3/24
ASPATH: 4 3
COMMUNITY: 4:8714 4:400

PREFIX: 2.2.2.2/24
ASPATH: 4 2
COMMUNITY: 4:8714 4:400
```

Multiple communities can tag different types of ingress points.

Deciphering location metadata in BGP



PREFIX: 1.0.0.0/24
ASPATH: 2 1 0
COMMUNITY: 2:100

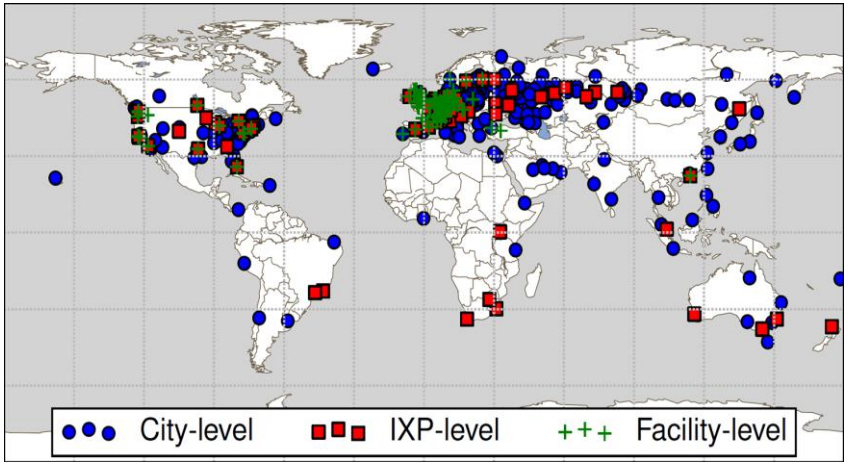
PREFIX: 3.3.3.3/24
ASPATH: 4 3
COMMUNITY: 4:400

PREFIX: 2.2.2.2/24
ASPATH: 4 2
COMMUNITY: 4:8714 4:400

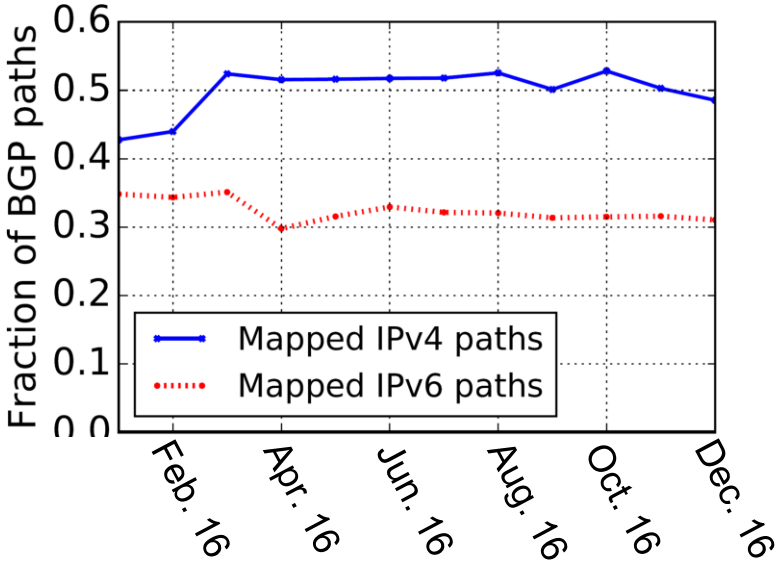
When a route changes ingress point, the community values will be update to reflect the change.

Interpreting BGP Communities

- Community values not standardized.
- Documentation in public data sources:
  - WHOIS, NOCs websites
- 3,049 communities by 468 ASes

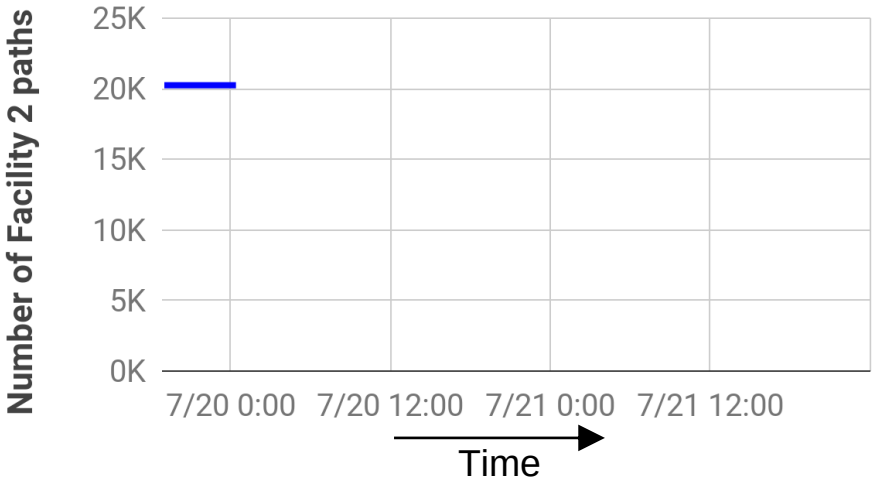


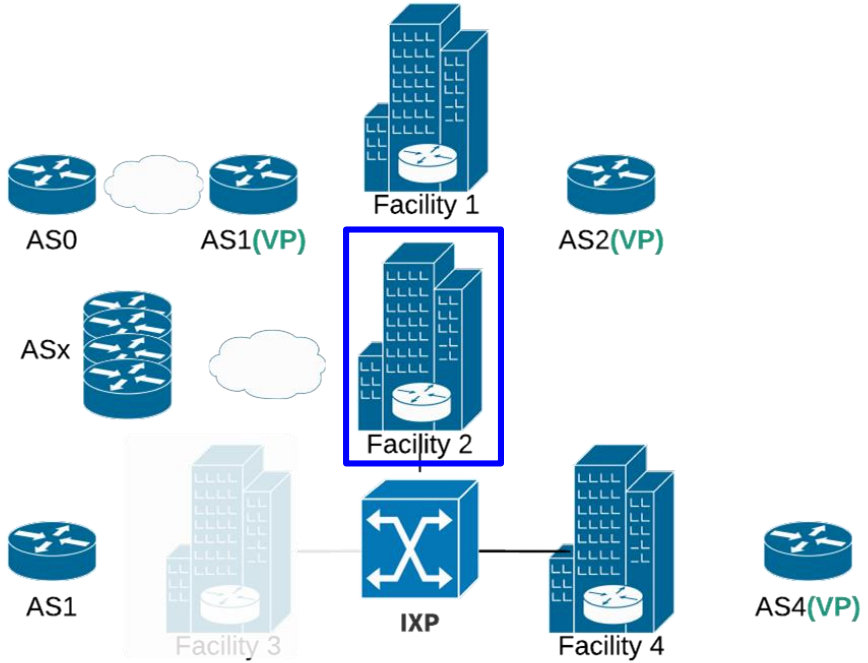
Topological coverage



- ~**50%** of IPv4 and ~**30%** of IPv6 paths annotated with at least one Community in our dictionary.
- **24%** of the facilities in PeeringDB, **98%** of the facilities with at least 20 members.

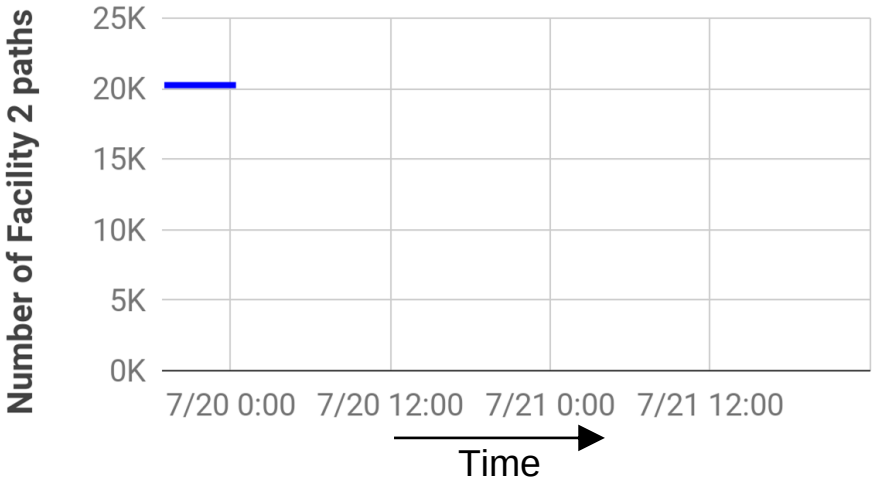
Passive outage detection: Initialization

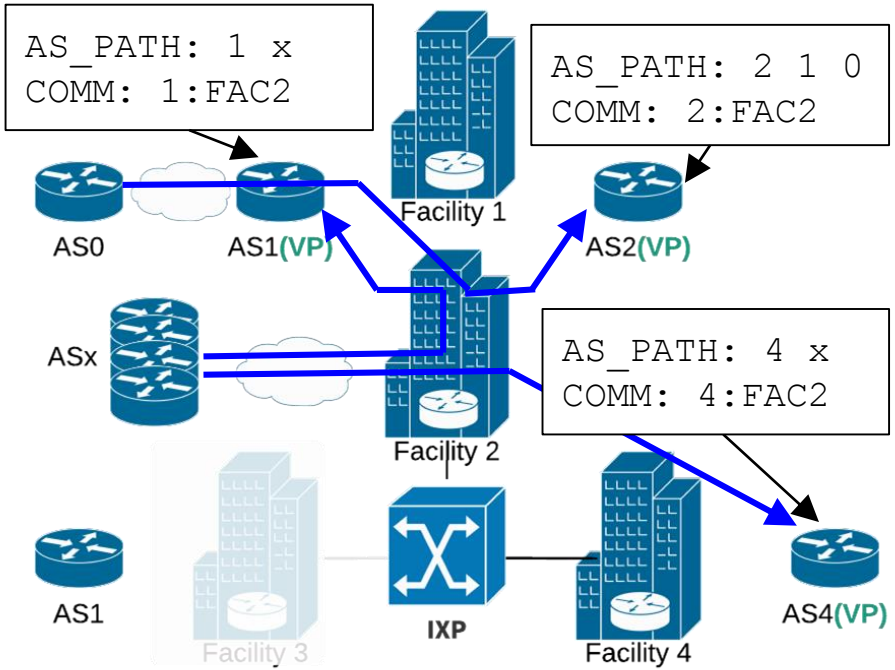




For each vantage point **(VP)** collect all the **stable** BGP routes tagged with the communities of the target facility (Facility 2)

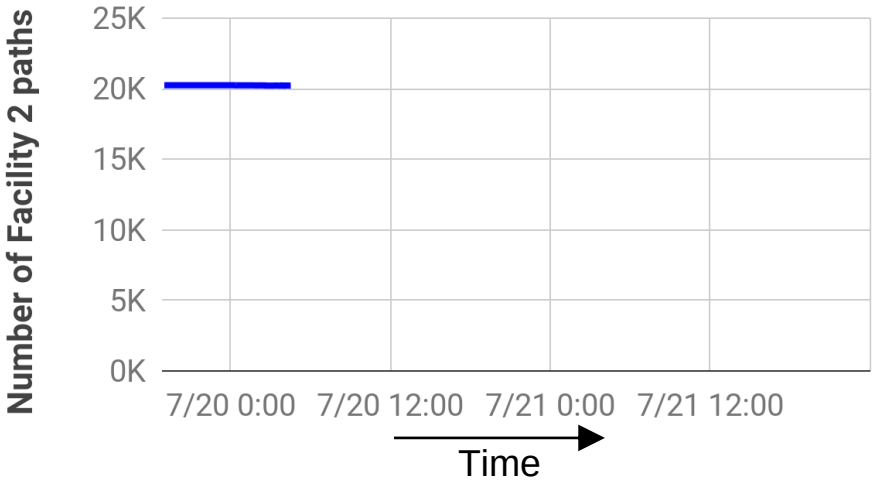
Passive outage detection: Initialization

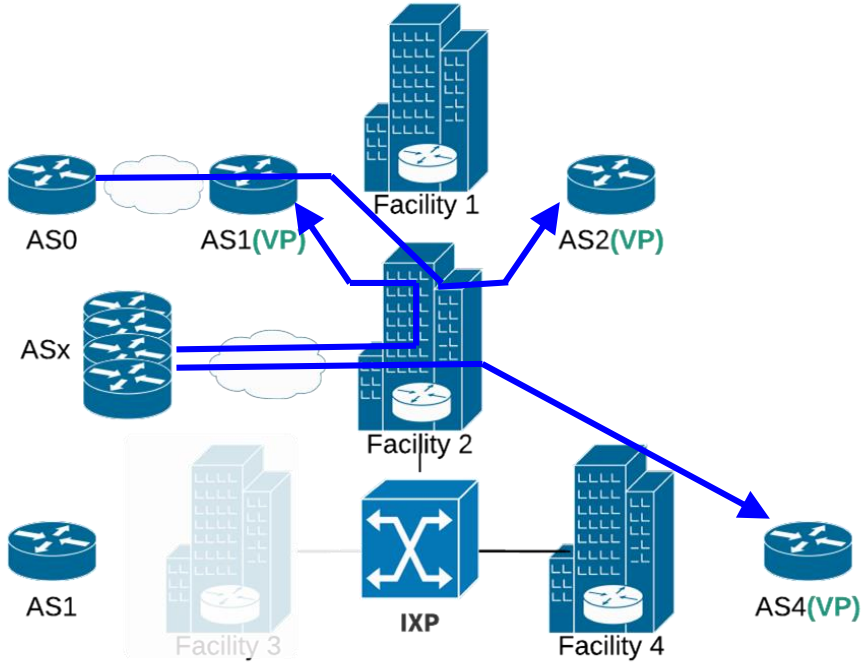




For each vantage point **(VP)** collect all the **stable** BGP routes tagged with the communities of the target facility (Facility 2)

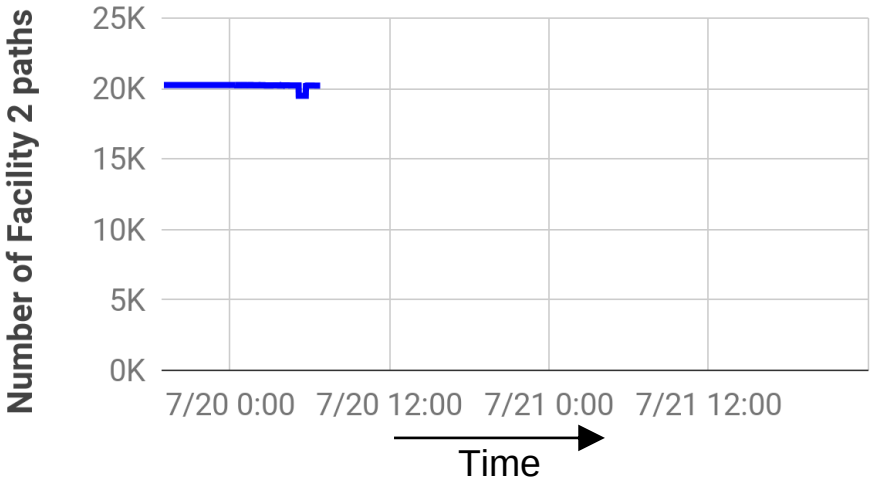
Passive outage detection: Monitoring

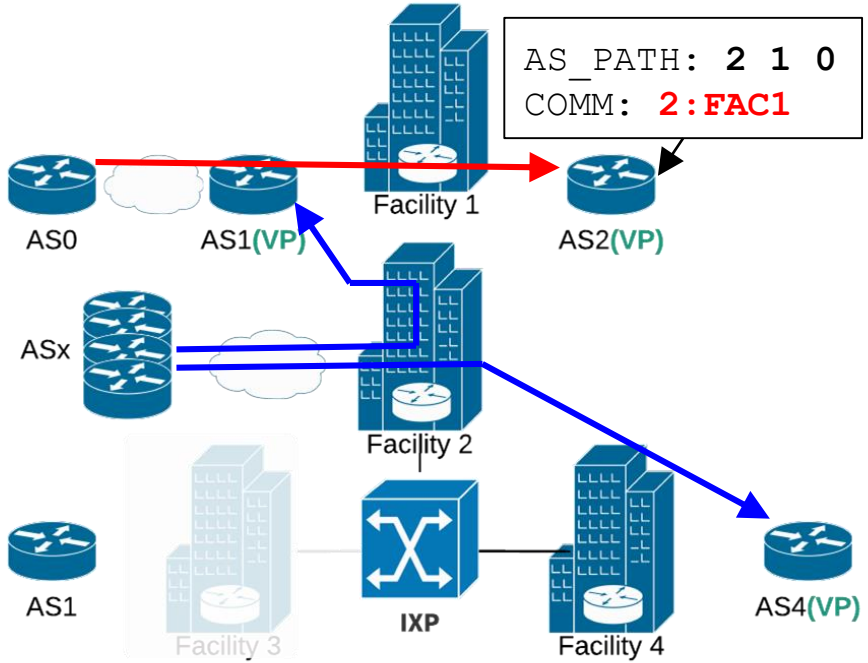




Track the BGP updates of the stable paths for changes in the communities values that indicate ingress point change.

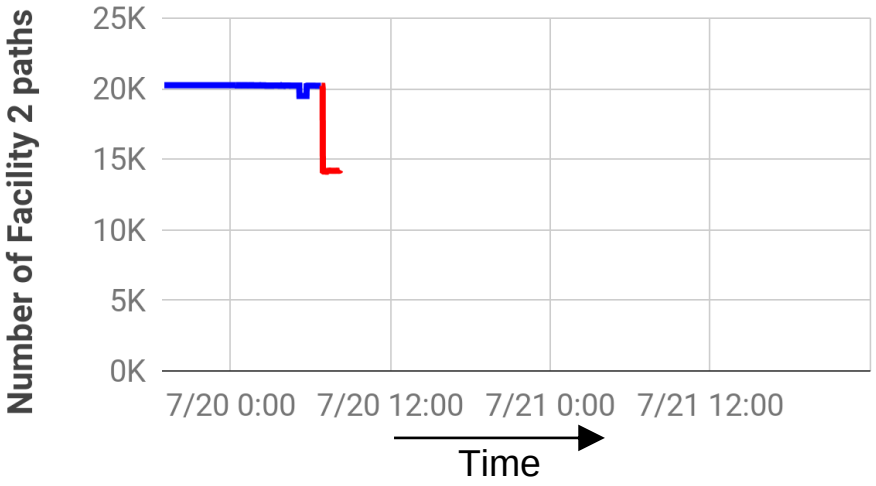
Passive outage detection: Monitoring

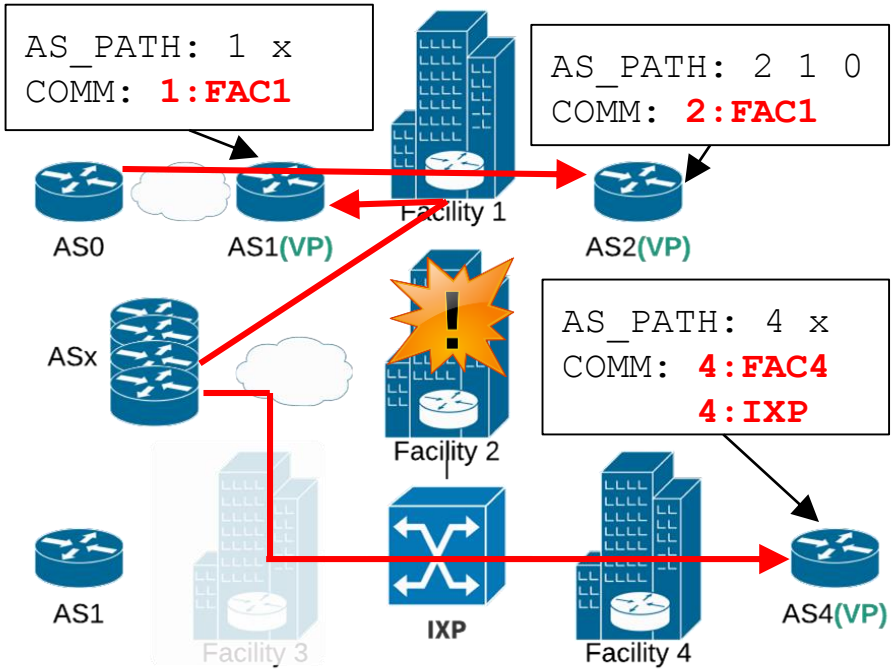




We don’t care about AS-level path changes if the ingress-tagging communities remain the same.

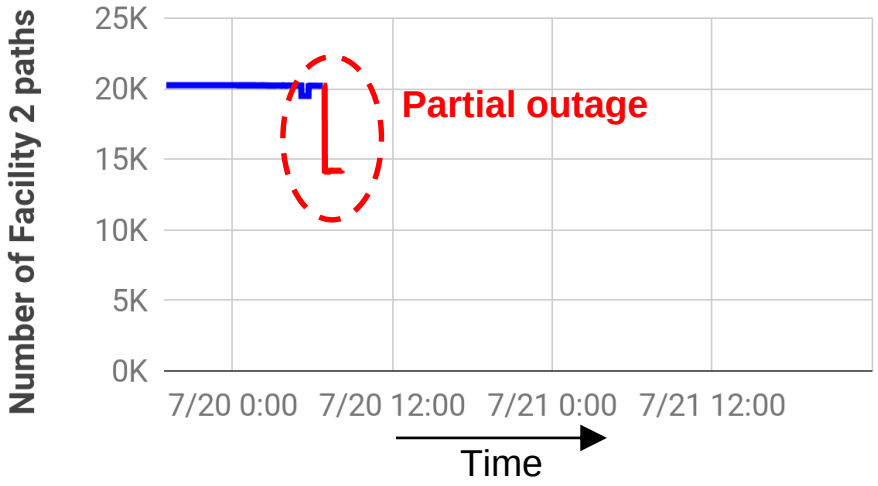
Passive outage detection: Outage signal

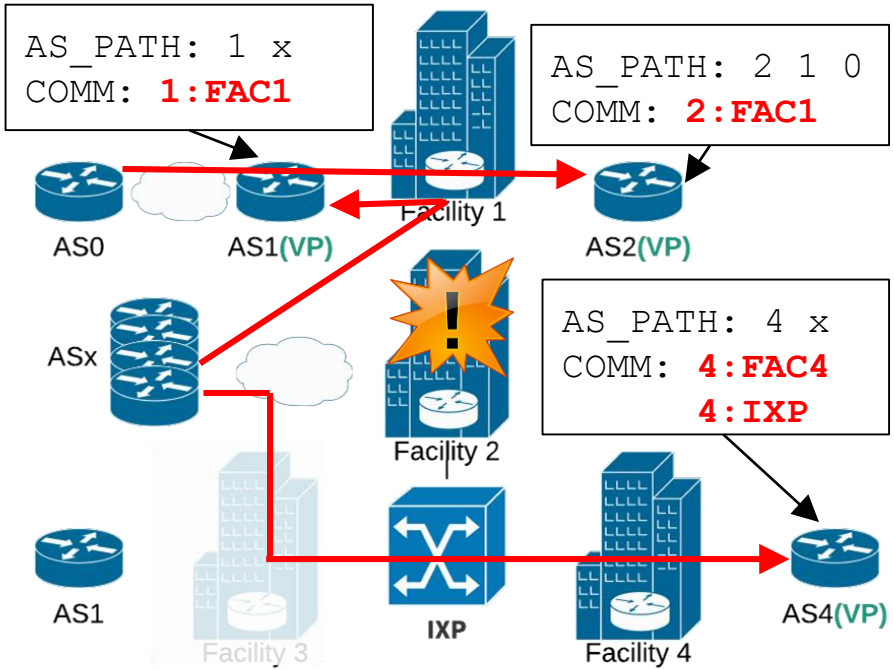




- Concurrent changes of communities values for the same facility.
- **Indication** of outage but not final inference yet!

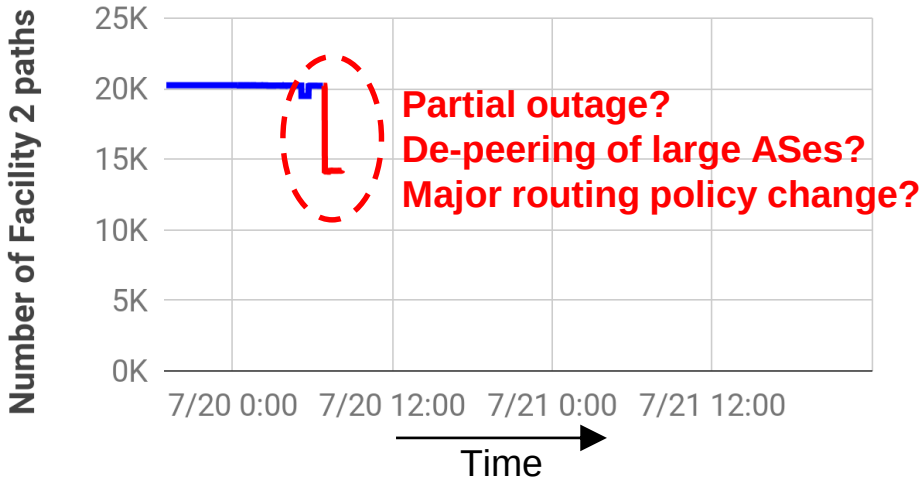
Passive outage detection: Outage signal

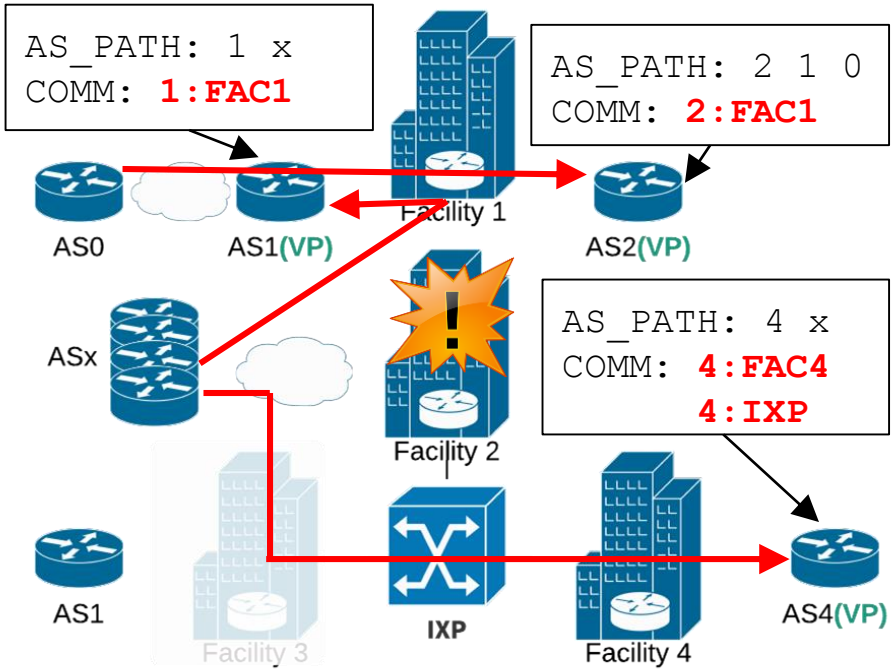




- Concurrent changes of communities values for the same facility.
- **Indication** of outage but not final inference yet!

Passive outage detection: Outage signal





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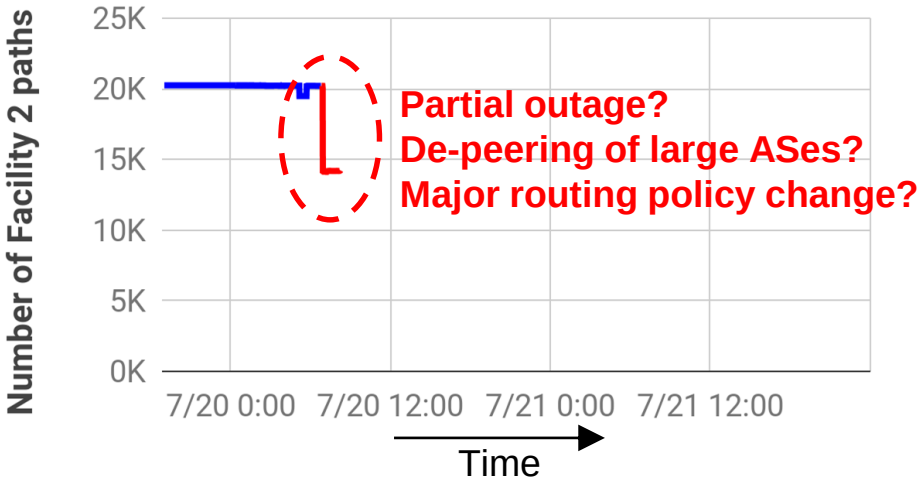
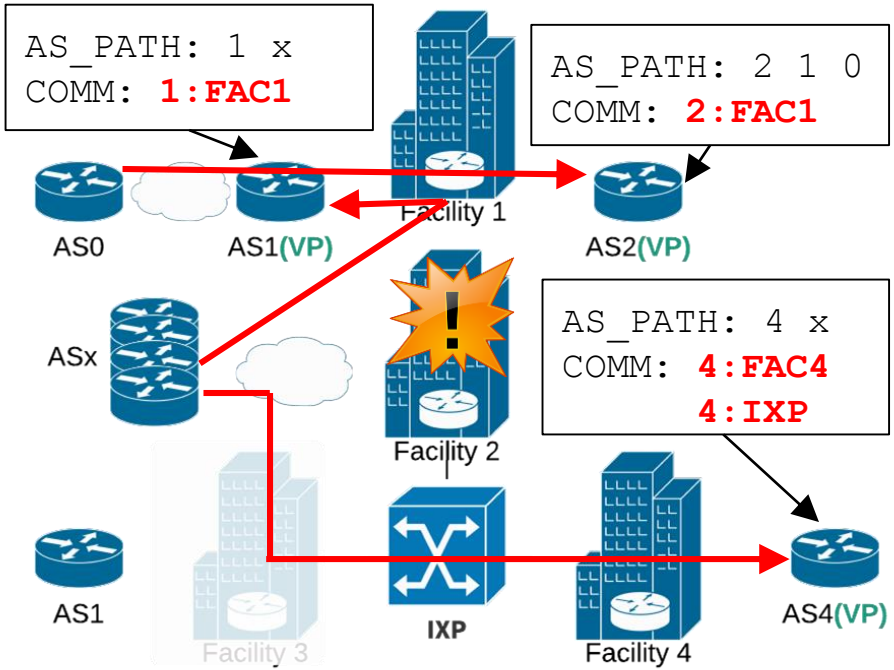
Passive outage detection: Outage signal

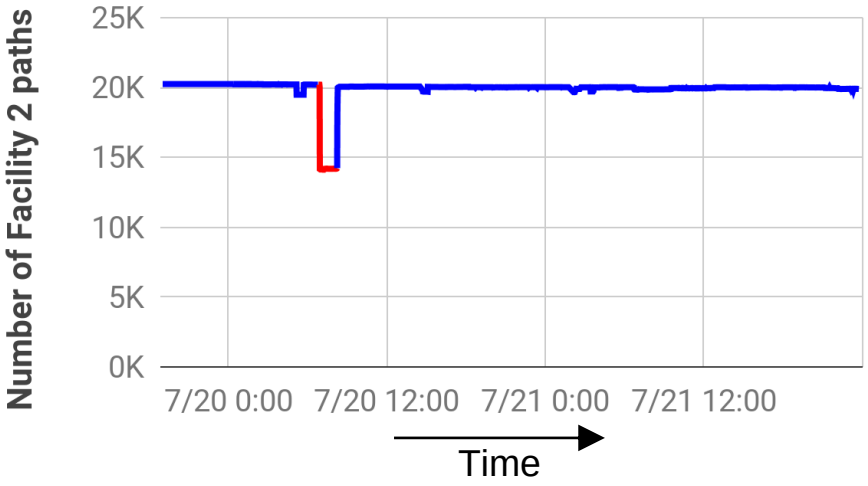


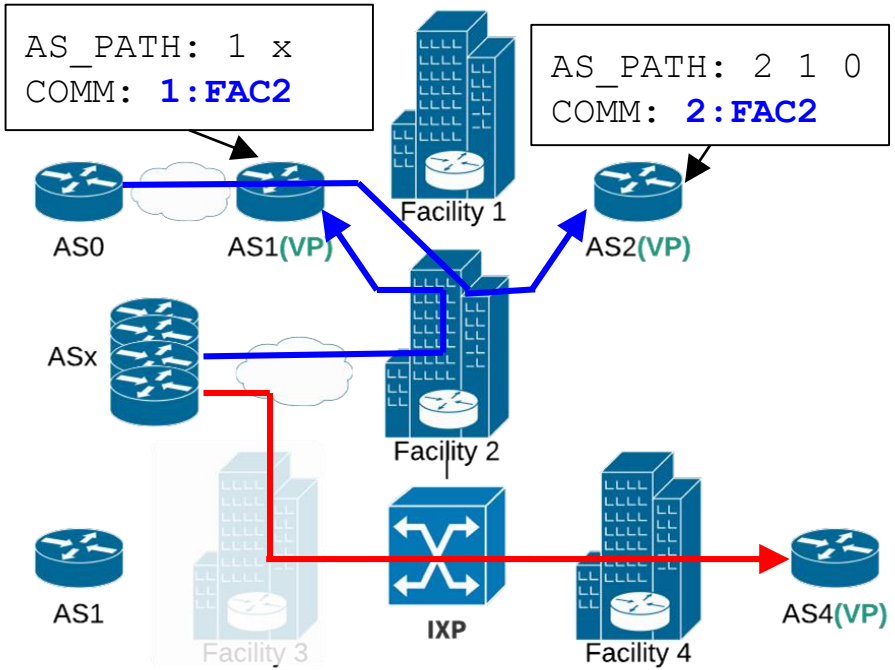


Signal investigation:

- Targeted active measurements.
- How disjoint are the affected paths?
- How many ASes and links have been affected?

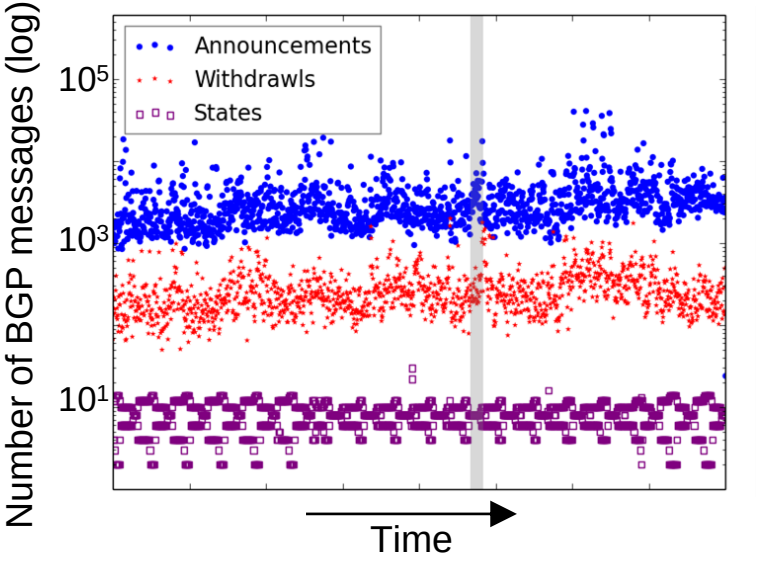
Passive outage detection: Outage tracking





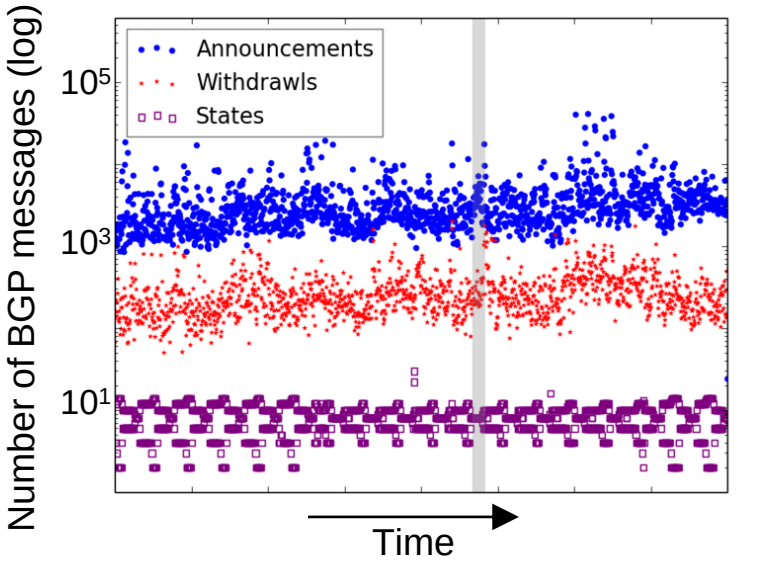
End of outage inferred when the majority of paths return to the original facility.

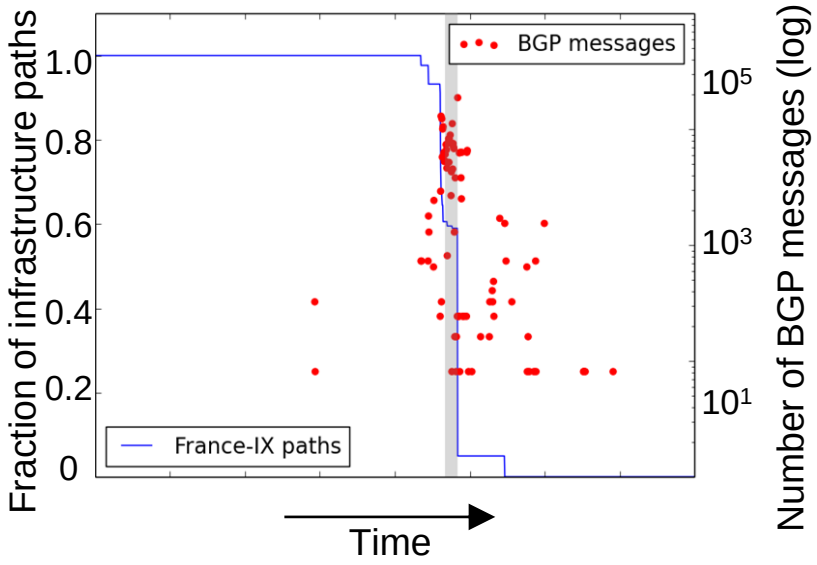
De-noising of BGP routing activity



The aggregated activity of BGP messages (updates, withdrawals, states) provides no outage indication.

De-noising of BGP routing activity





The aggregated activity of BGP messages (updates, withdrawals, states) provides no outage indication.

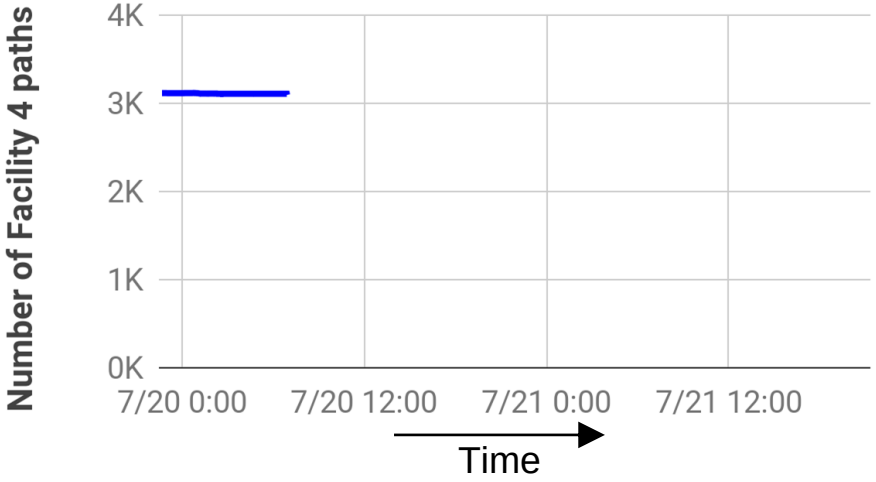
The BGP activity filtered using communities provides **strong outage signal**.

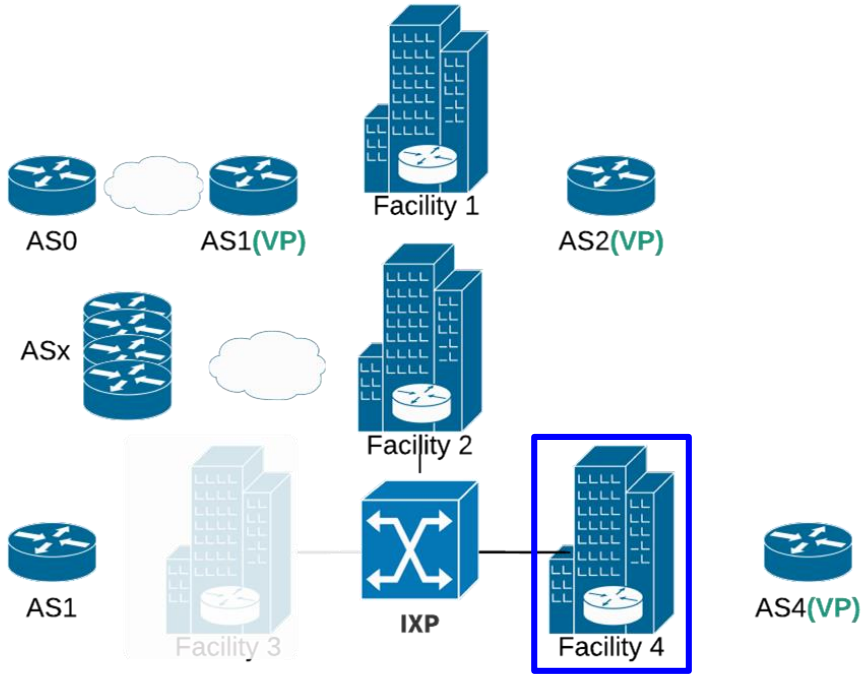
Outage localization is more complicated!

- The location of community values that trigger outage signals may not be the outage source!

- Communities encode the ingress point closest (**near-end**) to our VPs:
  - ASes may be interconnected over multiple intermediate infrastructures
  - Failures in intermediate infrastructures may affect the near-end infrastructure paths

Outage localization is more complicated!





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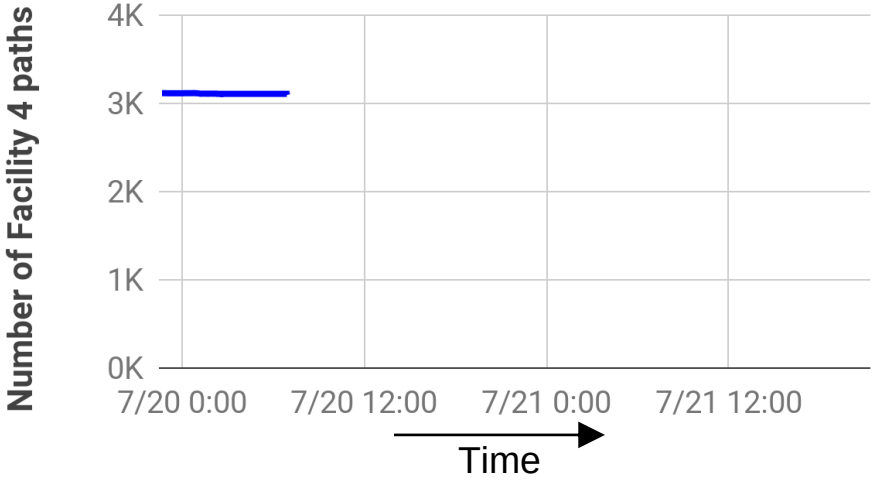

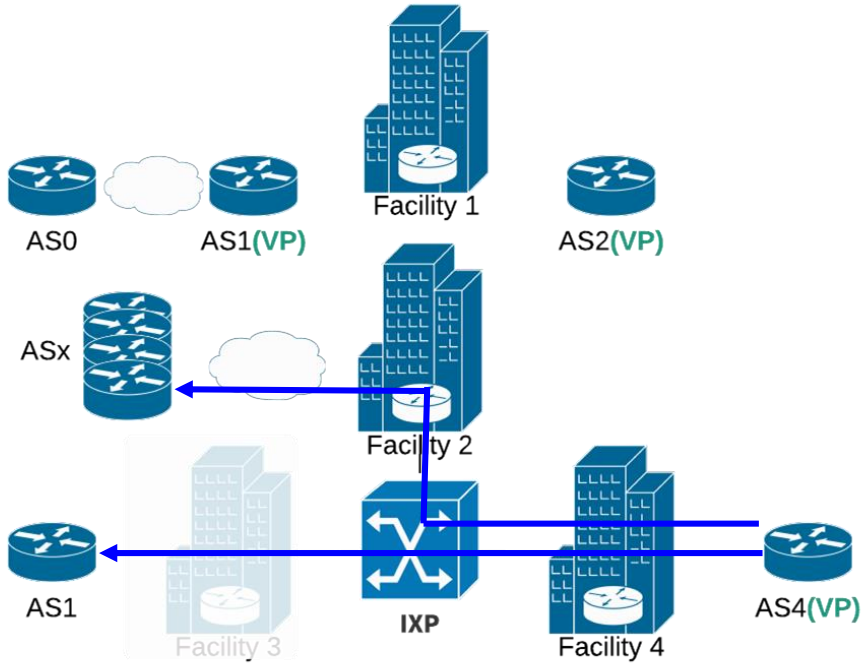

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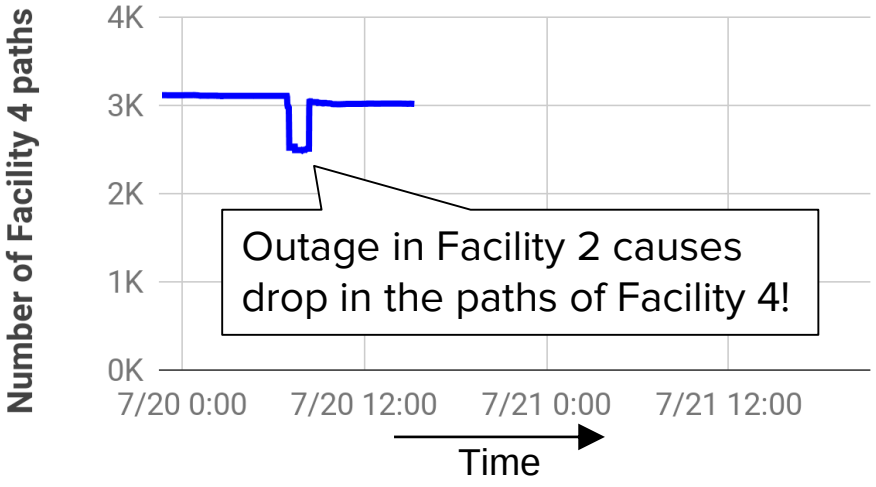

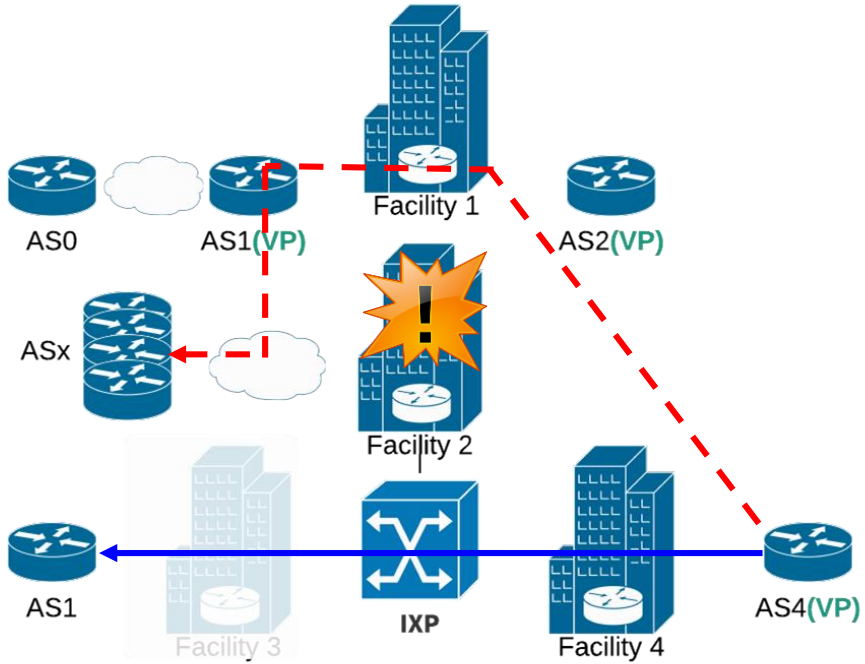

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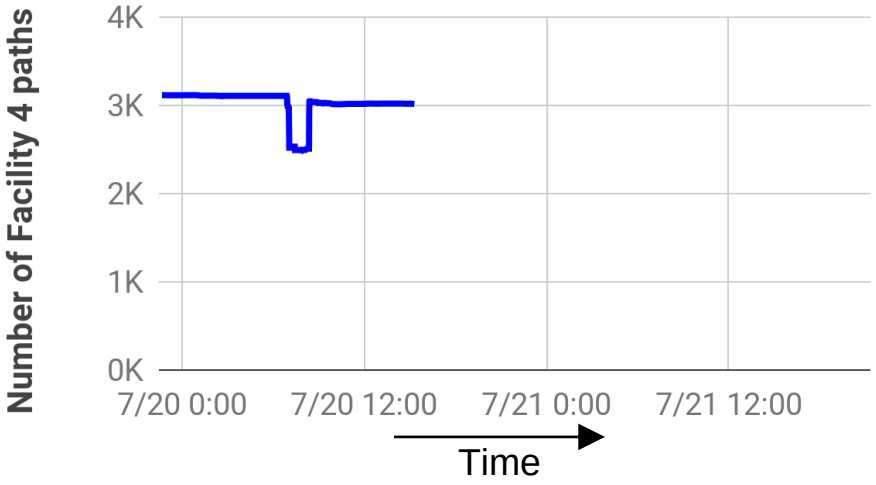

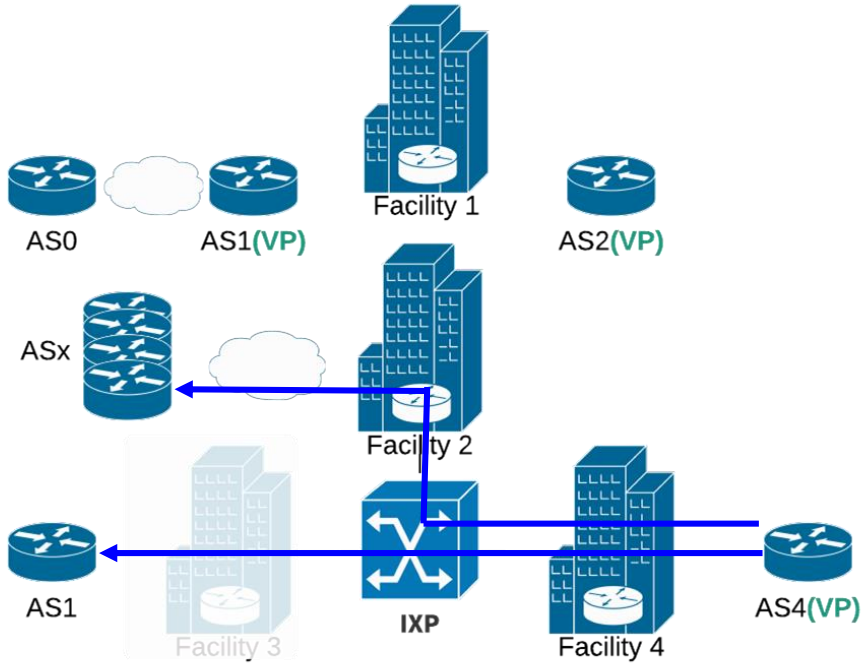

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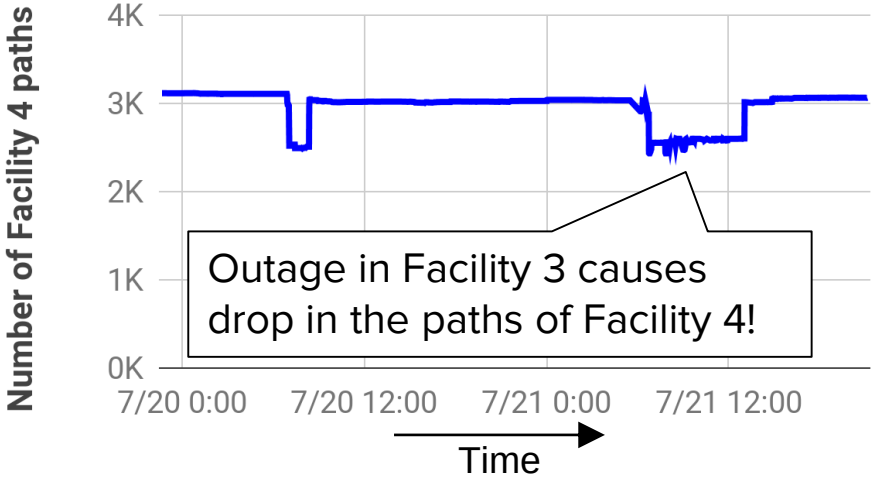
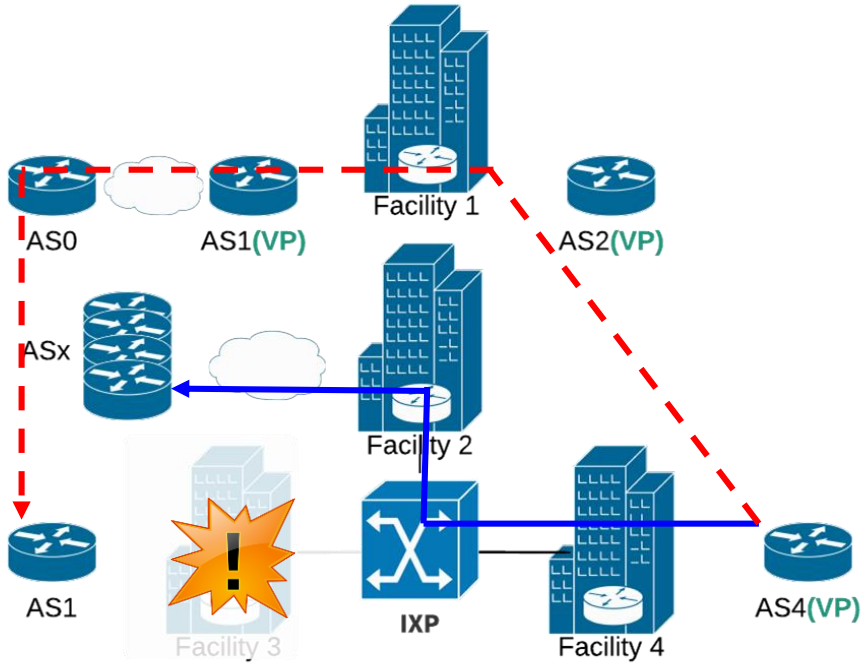


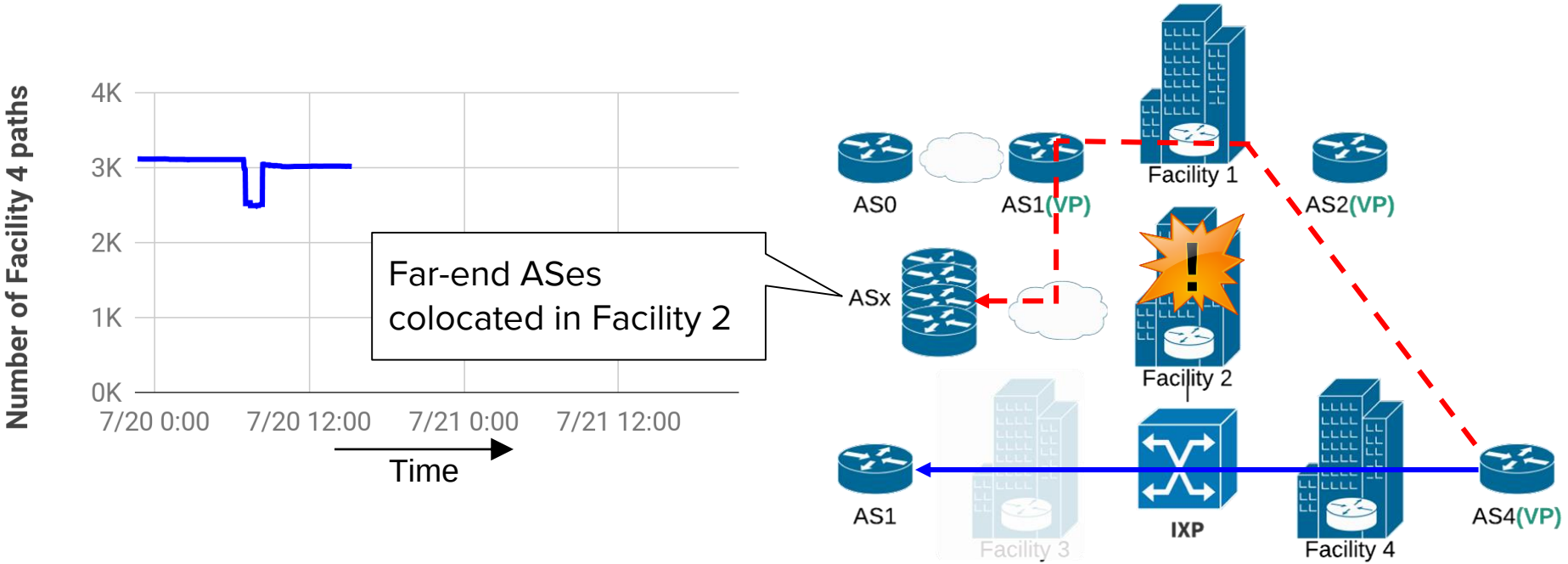


Outage source disambiguation and localization

- Create **high-resolution co-location maps**:
  - AS to Facilities, AS to IXPs, IXPs to Facilities
  - Sources: PeeringDB, DataCenterMap, operator websites

- Decorrelate the behaviour of affected ASes based on their infrastructure colocation.

Outage localization is more complicated!



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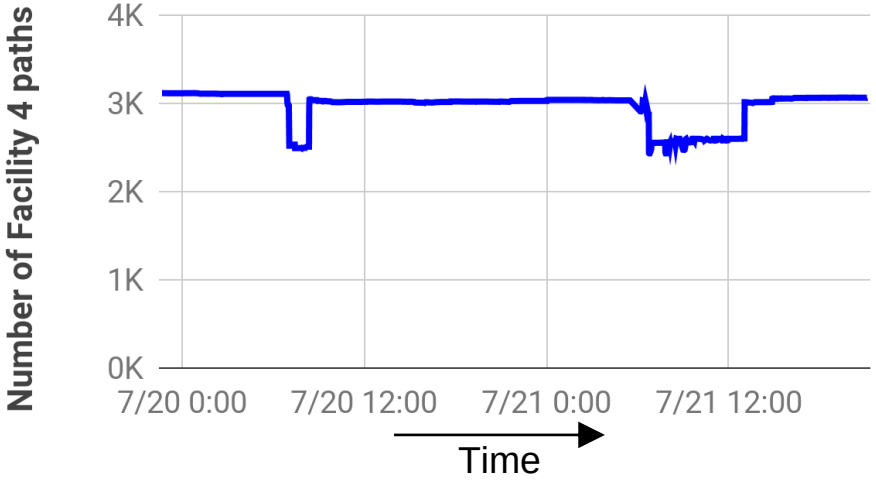
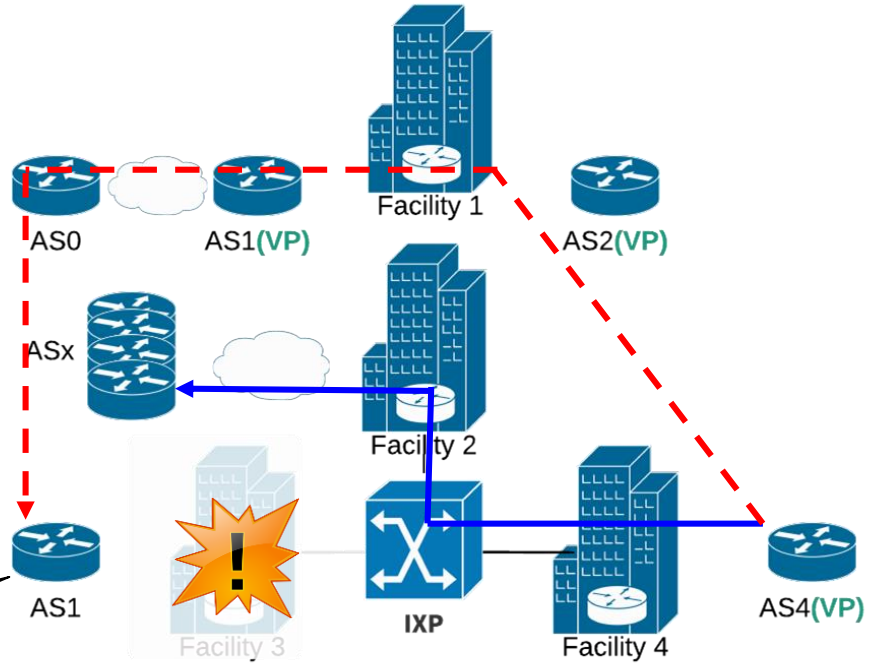
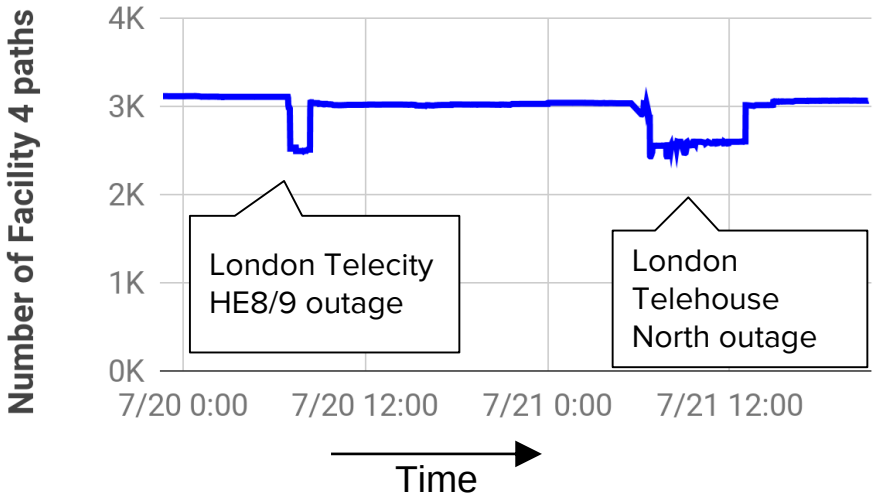


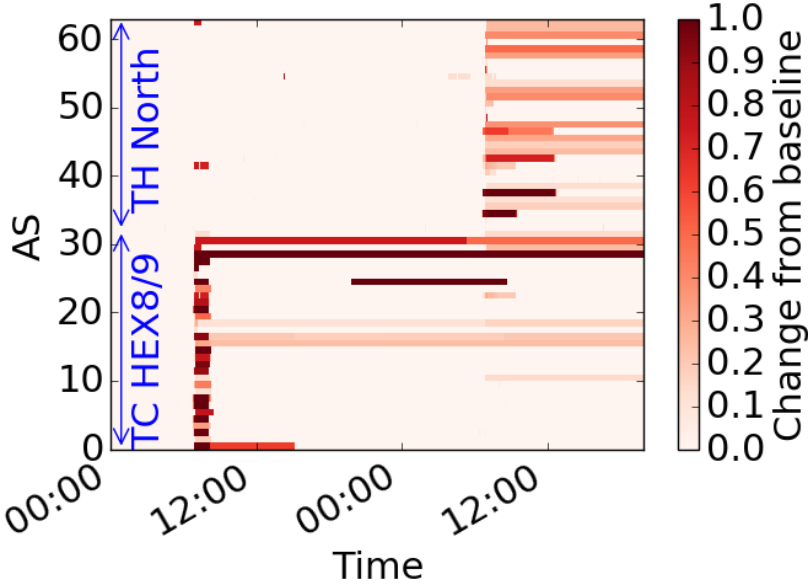


Far-end ASes colocated in Facility 3

Outage source disambiguation and localization

Paths not investigated in aggregated manner, but at the granularity of separate (AS, Facility) co-locations.





Outage source disambiguation and localization

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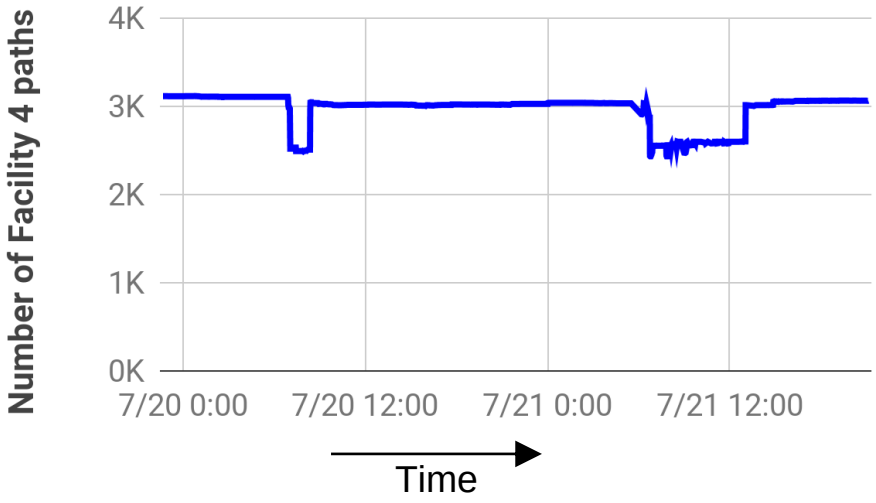
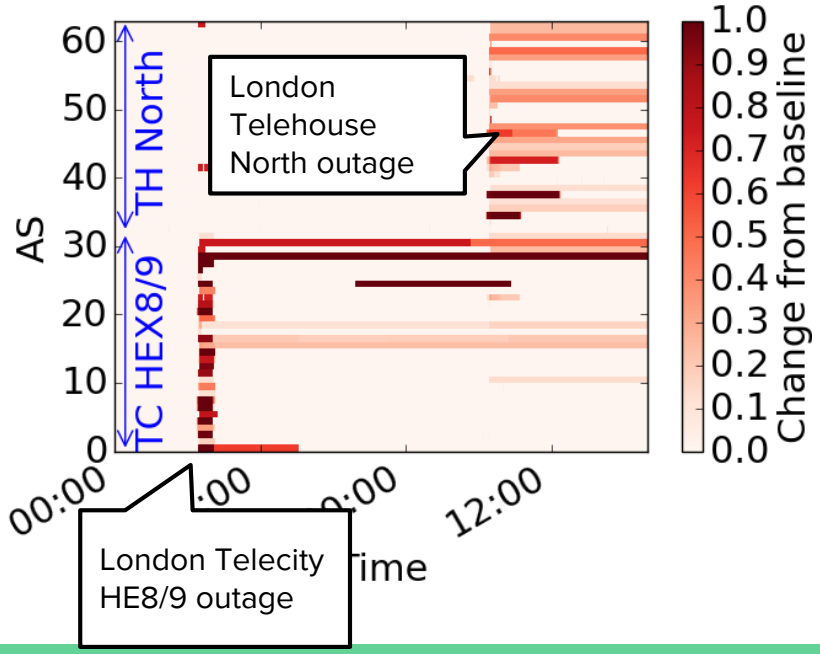
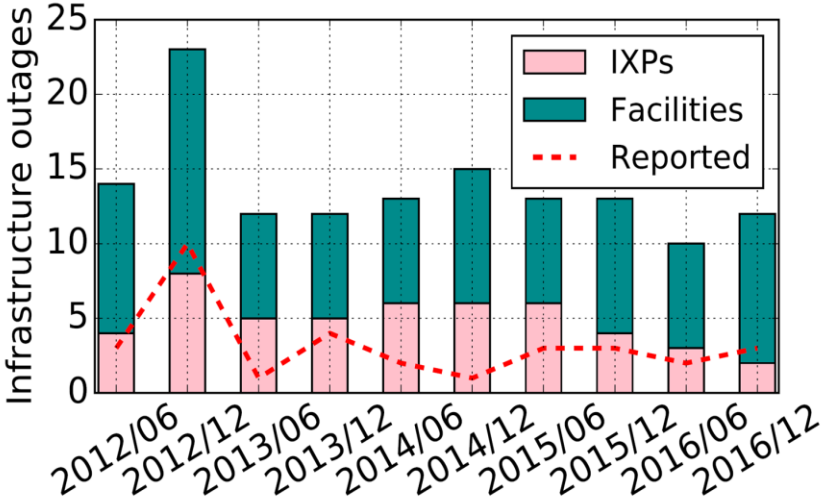


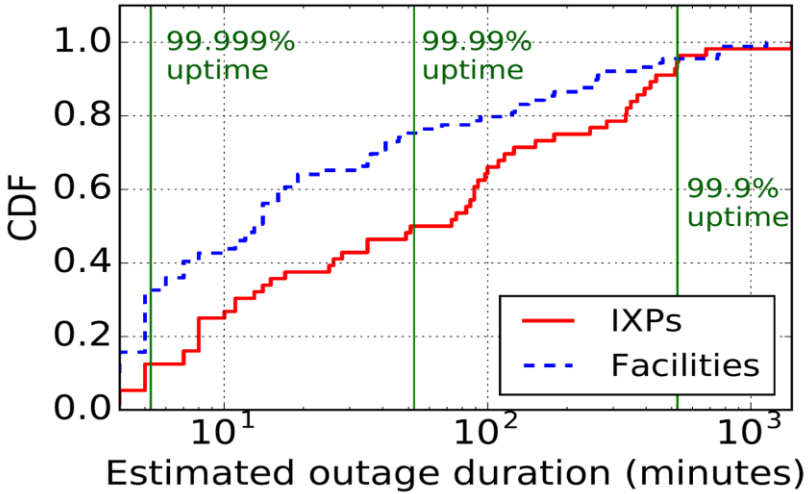


Detecting peering infrastructure outages in the wild



- **159** outages in 5 years of BGP data
  - **76%** of the outages not reported in popular mailing lists/websites
- Validation through status reports, direct feedback, social media
  - **90%** accuracy, **93%** precision (for trackable PoPs)

Effect of outages on Service Level Agreements

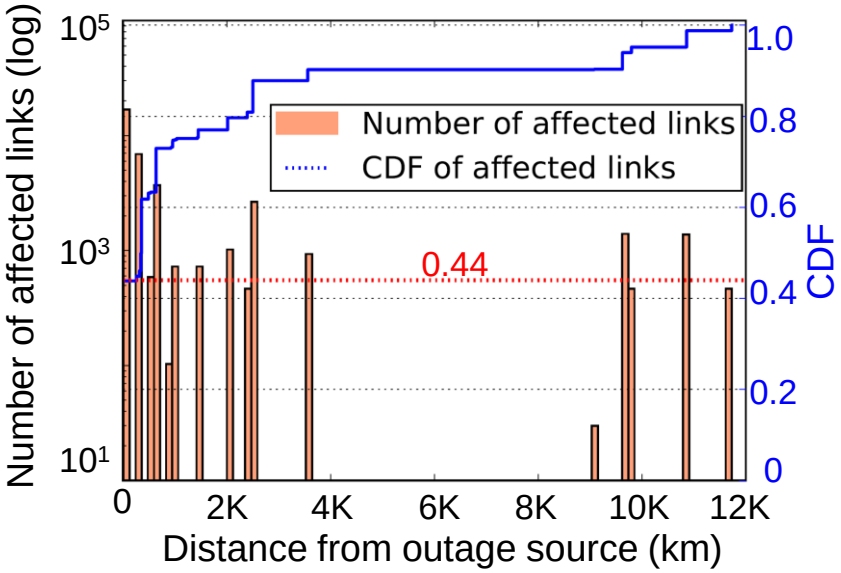


~**70%** of failed facilities below 99.999% uptime

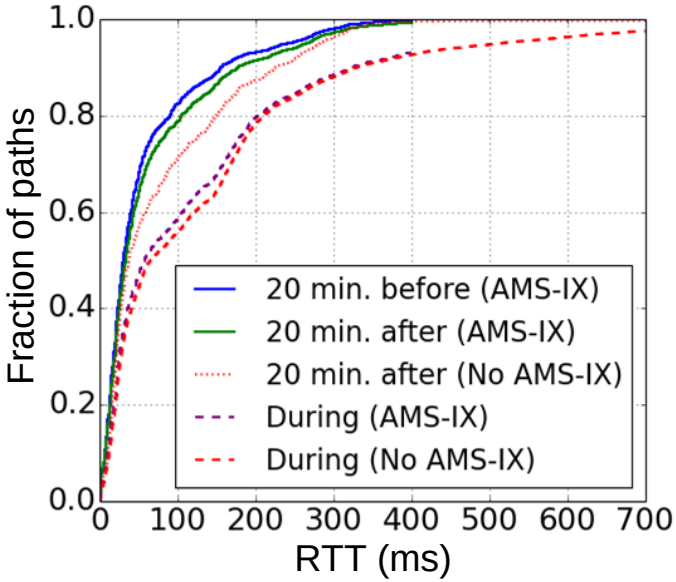
~**50%** of failed IXPs below 99.99% uptime

5% of failed infrastructures below 99.9% uptime!

Measuring the impact of outages



> 56 % of the affected links in different country, **> 20%** in different continent!



Median RTT rises by **> 100 ms** for rerouted paths during AMS-IX outage.

Conclusions

- **Timely** and **accurate** infrastructure-level outage detection through **passive** BGP monitoring
- Majority of outages not (widely) reported
- Remote peering and infrastructure interdependencies **amplify** the impact of local incidents
- **Hard evidence** on outages can improve accountability, transparency and resilience strategies

Thank you!

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